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June 8, 1989
SUPERSEDING
FAA-E-2570b,
5/1/84

U.S. Department of Transportation
Federal Aviation Administration
Specification

AUTOMATED RADAR TERMINAL AIR TRAFFIC CONTROL SYSTEM (ARTS IIA)

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AUTOMATED RADAR TERMINAL AIR TRAFFIC CONTROL SYSTEM ARTS IIA

1. Scope

1.1 Scope.- This specification describes the hardware and utility software requirements for the enhanced Automated Radar Terminal System, ARTS IIA. This system is intended for use at airports experiencing a low to medium level of air traffic. The ARTS IIA system will provide for the decoding of secondary radar data, the generation of target reports from this data, the tracking of beacon targets and the display of associated alphanumerics identification, Mode C altitude, and ground speed data. In addition, all controlled Mode C aircraft will be monitored and warnings displayed for aircraft that are in conflict with other aircraft or the terrain. The system will interface with ARTCC facilities and will exchange air traffic control data on-line. A training mode will be provided so the system can be used to train air traffic controllers in a mixed live/simulated environment.

The hardware is composed of three major subsystems, the interfaces between the subsystems and existing equipments.

The subsystems are the Decoding Data Acquisition Subsystem (DDAS), the Data Processing Subsystem (DPS) and the Data Entry, and Display Subsystem (DEDS).

Software consists of the operational program, utility programs, maintenance and diagnostic programs, and a system test program.

2. Applicable Documents

2.1 Specifications, Standards, and Publications.- The following specifications, standards, and publications form a part of this document and are applicable to the extent specified herein.

2.1.1 FAA Specifications

FAA-D-2494	Instruction Books, Manuscripts, Technical Equipment and Systems, Requirements, July 18, 1975
FAA-C-1217C	Electrical Work, Interior, September 15, 1967, and Amendment 4, April 9, 1970
FAA-E-2217	Digital Data Communications System, September 15, 1965, and Amendment 4, October 30, 1970
FAA-ER-D-120-12a	Engineering Requirement ARTS II Enhancements, October 1, 1981
FAA-E-2319b	Air Traffic Control Beacon Interrogator, September 7, 1971, and Amendment 2, September 27, 1972
FAA-E-2506	ASR-8 Specification, November 12, 1971, and Amendment 3, August 29, 1973
FAA-E-2512	Electron Tube Cathode Ray, Metal Cone, 22", Circular, December 1, 1971, and Amendment 1, February 9, 1973
FAA-G-1375b	Spare Parts Peculiar for Electronic, Electrical and Mechanical Equipment, August 14, 1981
FAA-G-1210c	Provisioning Technical Documentation, April 13, 1971, Amendment 1, October 17, 1972
FAA-G-2100e	Electronic Equipment, General Requirements, March 11, 1987 with Change 1, June 12, 1987.
FAA-S-2258	Digital Date Communications System Service, April 13, 1966, and Amendment 1, January 5, 1968

Reference hereafter in this specification of any basic specification cited in this paragraph 2.1.1 shall mean the inclusion of any amendment or supplement noted in this paragraph 2.1.1.

2.1.2 FAA Standards

FAA-STD-001a	Color and Texture of Finishes for National Airspace System, with Amendment 1
FAA-STD-002	Engineering Drawings
FAA-STD-010b	Graphic Symbols for Digital Logic Diagrams

FAA-STD-012a	Paint Systems for Equipment
FAA-STD-016a	Quality Control System Requirements, September 21, 1987
FAA-STD-018a	Computer Software Quality Program Requirements, September 30, 1987
FAA-STD-021	Configuration Management, August 7, 1981

2.1.3 FAA Publications

FAA-SMP-6040.15	National Airspace Performance Reporting System
NAS-MD-601	Interface Control Document NAS En Route Stage A-ARTS III
FAA Order 6000.15A	General Maintenance Handbook for Airway Facilities
NAS-MD-604 thru 612	ARTS III Beacon Tracking Level Computer Program Functional Specification, A0.17.
NAS-MD-903	ARTS IIA Computer Program Functional Specification, A2.06.
TM-PA-0006/008/00B	Software Design Data for ARTS II Enhancements
TM-PA-0006/006/01B	Coding Specification for ARTS II Enhancements

2.1.4 Military Specifications

MIL-E-17555	Electronic and Electrical Equipment and Associated Repair Parts, Preparation of Delivery of
MIL-E-27894A	Human Engineering Requirements for Aerospace Systems and Equipment
MIL-I-16910C	Interference Measurements, Electromagnetic Methods and Limits, October 26, 1964, and Amendment 3, October 17, 1966
404L-50464-CI-144	Prime Item Development Specification for DBRITE, 15 April 1985.

2.1.5 Military Standards

MIL-STD-188c	Military Communications System - Technical Standards
MIL-STD-470	Maintainability Program Requirements for Systems and Equipments, March 21, 1966
MIL-STD-471	Maintainability Demonstration

MIL-STD-721B	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety
MIL-STD-756A	Reliability Prediction, May 15, 1963
MIL-STD-781B	Reliability Tests, Exponential Distribution
MIL-STD-785	Requirements for Reliability Program
MIL-STD-803A-1	Human Engineering Design Criteria for Aerospace Systems and Equipment, Part 1
MIL-STD-803A-2	Human Engineering Design Criteria for Aerospace Systems and Equipment, Part 2
MIL-STD-826A	Electromagnetic Interference Test (USAF) Requirements for Test Methods, June 30, 1966
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-1130	Connection, Electrical Solderless, Wrapped

2.1.6 Military Publications

MIL-HDBK-217d	Reliability, Stress, and Failure Rate Data for Electronic Equipment, December 1, 1965

2.1.7 Federal Specifications

Federal Specification TT-E-527C Enamel Alkyd Lusterless

Federal Specification 11-C-4403

2.1.8 Federal Standards

Federal Standard 141a, Method 6103, Test Method

Federal Standard No. 595A Colors Volume 1

2.1.9 Industry Specifications.- The following industry specifications of the issue in effect on the date of invitation for bids or request for proposals form a part of this specification:

GTA-62-8-7	Glass Tempering Association Specification for Safety Windows for Laminating to TV Tubes

2.1.10 General Information.- The following documents have been referenced herein and will be available for use in the FAA headquarters building.

ER-D-130-013	Engineering Requirements for Tower Cab Radar Display-TV and Amendments 1, 2, 3, 4, and 5
ER-D-250-001a	Engineering Requirements for Azimuth Mark Pulse Amplifier, March 3, 1964

FAA-E-2306	Coded Time Source and Auxiliaries
PB-161894	RADC Reliability Handbook
NAS-MD-600	ARTS III System Description
FAA-TD/S-120-801A	ARTS III Beacon Tracking Level System
FAA-6050.0-1	Radar/Beacon Repetition and Frequency Assignment
FAA-E-2261a	Beacon Performance Monitor
SE007-4	ASR-9 External Interface Control Document for the ASR-9 SCIP to Terminal Computer, Revision C
TM-PA-0018/072/02	External Interface Control Document for Mode S to ASR-8 /ARTS IIA Terminal Sites, December 8,1986
TM-PA-0018/071/02	External Interface Control Document for Mode S to ASR-7 /ARTS IIA Terminal Sites, December 8,1986

Engineering Directives, which describe the latest equipment modifications should be used with the equipment instructions books and are listed below:

2.1.10.1 Beacon Equipment

2.1.10.1.1 Instruction Books

(a) Air Traffic Control Beacon Ground Station, Model ATCBI-3, Transmitter Site Equipment Group.

(b) Instruction Book Addendum for Air Traffic Control Beacon Ground Station, Model ATCBI-3B.

(c) Air Traffic Control Beacon Ground Station, Model ATCBI-3, Indicator Site Equipment Group.

(d) Air Traffic Control Beacon Station, Model ATCBI-2 Indicator Site Equipment Group.

(e) Beacon Video Defruiting Equipment (Storage Tube) Type FA-7281.

(f) Radar Beacon Test Set, Type FA-7270 and Type FA-7274.

(g) Air Traffic Control Beacon Station ATCBI-4, TI 6360.12.

(h) Interference Blanker MX-8737/UPX, Technical Manuals TM-NAVELEX 0967-426-5010.

(i) ATCRBS I/R site test set, FA-8169, TI 6360.11A

(j) Air Traffic Control Beacon Interrogator, Model ATCBI-5, TI-6360.70

2.1.10.2 Microwave Link Equipment

2.1.10.2.1 Instruction Books

(a) Radar Microwave Link System, RML-2

(b) Radar Microwave Link System, RML-3

(c) Radar Microwave Link System, RML-4

(d) Radar Microwave Link System, RML-1A

(e) Radar Microwave Link System, RML-5

(f) Radar Microwave System, RML-6 TI 6350.1A

2.1.10.2.2 FAA Directives AF P 6350

2.1.10.3 Airport Surveillance Radar

2.1.10.3.1 Instruction Books

(a) Airport Surveillance Radar, ASR-3

(b) Equipment Modification Set for Airport Surveillance Radar, Model ASR-3

(c) Airport Surveillance Radar Antenna System ASR-1, -2, -3 Type FA-5144

(d) Airport Surveillance Radar ASR-3B Improvement Instructions

(e) Airport Surveillance Radar ASR-4, Type FAA-4700

(f) Airport Surveillance Radar, ASR-5, (AN-FPN-47), Type FA-4900

(g) Airport Surveillance Radar, ASR-6, Type FA-5900 (ASR-6 uses FA-5144 antenna)

(h) Airport Surveillance Radar Display System (ASRDS) Type FA-7300

(i) Airport Surveillance Radar Display System (ASRDS-2), Type FA-7700

(j) Airport Surveillance Radar Display System (ASRDS-3)

(k) Instruction Book ASR-7 TI 6310.4A

(l) Instruction Book ASR-8, TI 6310.13

2.1.10.3.2 FAA Directives AF P 6310.1

2.1.10.4 Video Mapping Equipment

2.1.10.4.1 Instruction Books

(a) Dual Mapping Group, Type FA-5450A

(b) Dual Mapping Group, Type FA-5400

(c) Video Mapping Group, Type FA-5100A

(d) Dual Mapping Group, Type FA-5450

(e) Video Mapping Group, Type FA-5100

(f) Air Route Surveillance Radar, ASR - (Contains Video Mapping Group CA-4110)

(g) Video Mapping Group, Type FA-8049

2.1.10.4.2 FAA Directives

(a) F P 6300

2.2 Precedence of Documents.- When the requirements of the contract schedule, this document, or subsidiary applicable documents are in conflict, the following precedence shall apply. The contract schedule shall have precedence over all other documents. This document shall have precedence over all subsidiary applicable documents referenced herein.

(Copies of this specification and of the applicable FAA Specification Drawings, any be obtained from Federal Aviation Administration, Washington, D.C. 20591, Attn: Contracting Officer. Requests should fully identify material desired, i.e., specification numbers, dates, amendment numbers, complete drawing numbers; also, request for proposals, or the contract involved, or other use to be made of the material requested).

(Single copies of military specifications may be obtained from Commanding Officer, Naval Publications, and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.)

(Information on obtaining copies of Federal Specifications and Standards may be obtained from the General Services Administration Offices in Washington, D.C., Seattle, San Francisco, Kansas City, Missouri, Chicago, Atlanta, New York, Boston, Dallas, and Los Angeles.)

(Individual copies of the industrial specification may be obtained by requesting same from the Glass Tempering Association, 1325 Topeka Avenue, Topeka, Kansas, 66612, Attn: Mr. William J. Birch.)

3. Requirements.- This section serves to set forth the requirements for the ARTS IIA system.

3.1 Definitions

3.1.1 General

3.1.1.1 Active Element.- Any component, unit, part, or subsystem currently being used to support ongoing ATC activities.

3.1.1.2 Alpha-Numeric Time Period.- The time available for riting alpha-numeric data during the normal radar dead time plus any additional time made available by limiting the system to a broadband radar display capability of 55 nautical miles.

3.1.1.3 Association.- A beacon target is associated with a control position when paired with that position in table(s) in the data base. Associated targets may transpond discrete or non-discrete codes. A discrete target becomes associated with a control position through a controller keyboard action or interfacility or bulk store flight plan. A non-discrete target becomes associated through a controller keyboard action only. A control position may be associated with many targets.

3.1.1.4 Auto-Termination, Auto-Acquire.- The automatic disassociation or association respectively of a discrete beacon target with a control position and a known aircraft identification. This normally takes place upon the targets penetrating or leaving pre-defined geographical areas.

3.1.1.5 Beacon Sync Trigger.- A signal which will precede beacon zero range by a fixed time interval.

3.1.1.6 Dead Time.- The time between maximum system range and the next radar or beacon trigger.

3.1.1.7 Defruit.- Eliminate non-synchronous beacon replies.

3.1.1.8 Discrete Capability.- Aircraft having the capability to transpond any 12 bit discrete code.

3.1.1.9 Discrete Code.- A twelve bit code expressed as four octal digits whose last two digits are not both zero.

3.1.1.10 Framing Pulses.- This is an indicator detected by the BRG which indicates that 2 pulses, nominally 20.3 ± .1 usec apart have been sensed. These framing pulses do not necessarily indicate the presence of an actual aircraft.

3.1.1.11 Fruit.- Non-synchronous transponder replies initiated by interrogations from another site.

3.1.1.12 Garble.- When two beacon replies are received within 40 usec and the leading edges of the pulses are overlapped, the replies are considered "garbled".

3.1.1.13 Modular Expansion.- The ability to add functional capabilities by replacing plugable modules in existing equipments and/or addition of modules or units without redesign of the existing equipments.

3.1.1.14 Non-Discrete Code.- A six bit code expressed as four octal digits the last two of which both are zero.

3.1.1.15 Off-the-shelf Equipment.- Is a unit of equipment which has been produced, delivered, and is performing its designed function at the time of proposal submission. Off-the-shelf equipment shall meet those requirements of FAA-G-2100e which this specification notes as applicable to off-the-shelf equipment and all the requirements (e.g., reliability, maintainability, environmental, functional, performance, RFI integrity, acoustical noise, etc.) imposed by this specification. Certified proof of sales, delivery and performance shall be furnished to the FAA Contracting Officer upon request. Testing shall be conducted in accordance with section 4 of this specification to verify compliance with all requirements of this specification. The Decoding Data Acquisition Subsystem, and Data Entry and Display Subsystem equipments (excluding TV cameras) shall not be classified as off-the-shelf, even if it meets the above requirements.

3.1.1.16 Positional Entry Module.- A pressure sensitive device which is used by the controller to indicate a position on his display.

3.1.1.17 Primary Airport.- That airport defined by site adapted parameters as the one about which auto-termination and auto-acquire areas are located.

3.1.1.18 Redundant Element.- Redundant elements are those system elements which are not presently being used to perform a useful function, but which are required as backup equipment to replace active equipments in the event of a failure.

3.1.1.19 Reply Message.- A code message formed in the BRG. This message is the result of a reply to a single interrogation and does not constitute a target report.

3.1.1.20 Scan.- One antenna rotational period.

3.1.1.21 Special Code .- Certain discrete and non-discrete codes are designated special because of unique actions required from the system when they are detected. The actions required upon detecting these codes are detailed in the specification. Three of these codes will be non-discrete (7700, 7600, 7500) and one (1236) will be discrete. Designation of the 7500 code and the special discrete code will be changeable parameters in the ARTS II computing unit.

3.1.1.22 Special Position Indicator (SPI).- A special pulse, used for identification purposes, which occurs 4.35 usec after the last beacon framing pulse.

3.1.1.23 Support Software.- All software provided for the system other than that used for the on-line processing of air traffic control functions. This software is divided into two categories - utility (assembler, loader, debugger, etc.) and maintenance (diagnostics, etc.).

3.1.1.24 System.- A system is defined as that configuration of elements which comprise an operational terminal ATC system at a given installation.

3.1.1.25 Site Adaptive Parameter.- A system variable which can be easily changed to accommodate the requirements of each site. Changes to system parameters shall not require reassembly of the program.

3.1.1.26 Target Message.- A message which is the result of a target detection process.

3.1.1.27 TRACAB.- The sum of all equipments used to provide terminal radar service from a tower cab.

3.1.1.28 TRACON.- The sum of all the equipments used to provide terminal radar service primarily from an IFR room.

3.1.1.29 Validation.- A code is validated when a sufficient number of clearly discernible replies have been received to declare that a target is transponding a particular code.

3.1.2 Classification of Displayed Data

3.1.2.1 Data Block-Full (FDB).- A position symbol and a leader and two or three lines of data. The first line generally contains the aircraft identification and the second line contains altitude, special situation data, as appropriate, and ground speed, the optional third line contains conflict and low altitude alert warnings.

3.1.2.2 Data Block-Limited (LDB).- A target symbol and a leader, and two lines of data. The first line contains the four digit beacon code and the second line contains altitude. The LDB will be displayed, consistent with controller selected output controls, for targets not associated with an aircraft identification.

3.1.2.3 Data Block-Single Symbol (SS).- These may be any symbol and will mark all beacon responses which are not being displayed as FDB's or LDB's on a particular display.

3.1.2.4 Preview Area (PRE).- An area on the controllers display where an input message is displayed as it is entered from the keyboard.

3.1.2.5 Tab Area (TAB).- An area on the controllers display listing flight plan data on aircraft which have not entered the system.

3.1.2.6 System Area (SYS).- An area on the controllers display containing system data (e.g., clock time, altimeter setting, selected codes, altitude filter limits).

3.1.2.7 Coast/Suspend Area.- An area on the controllers display listing all aircraft that are no longer being tracked because sensor data is no longer being received or tracking has been suspended through a keyboard action.

3.1.2.8 Alert Area. .n area on the controllers disp , containing data on aircraft or aircraft pairs that are in conflict with the terrain or other aircraft.

3.1.3 Subsystems

3.1.3.1 Decoding Data Acquisition Subsystem (DDAS).- That subsystem comprised of the elements responsible for detection, code extraction and garble sensing of beacon replies. It also includes the Analog Channel and Decoder.

3.1.3.2 Data Processing Subsystem (DPS).- That subsystem comprised of modules for computing, memory, input/output control and communications and peripheral equipment adapters. The operational and the support software are also part of this subsystem.

3.1.3.3 Data Entry and Display Subsystem (DEDS).- That subsystem comprised of alphanumeric keyboards, display control panels, positional entry modules, the controller displays and all the equipment necessary to interface these units to the DPS, DDAS, and the primary radar systems.

3.1.4 Reliability

3.1.4.1 Mean Down Time (MDT).- Mean down time is defined as the mean time to effect and verify repair of the system sufficient to put the system in condition to perform its intended function.

3.1.4.2 Mean Time Between Failure (MTBF).- Mean time between failure, expressed in hours, is defined as the reciprocal of the failure rate of an element. (MTBF =1/ λ where = unit failure rate).

3.1.4.3 Mean Time to Repair (MTTR).- Mean time to repair is defined as the mean time to effect and verify repair of the element to put the element in an "up" condition.

3.1.4.4 Mean Up Time (MUT).- Mean up time is defined as the mean time to failure of the system given that the system was performing its intended function at time zero.

3.1.4.5 Classes of Failures.- Two classes of failures are defined:

(a) Transient Failure.- Self-clearing transient disturbances, such as transient parity errors, which do not require deactivation of an active element, and

(b) Non-transient Failure.- Non-clearing failures of an active element requiring deactivation of the element. This class shall also include failures of devices such as vidicons and monoscopes which preclude their ability of meeting their required performance levels.

3.1.4.6 Unit Failure Rate (λ).- Unit failure rate is defined as the sum of the individual component density failure rates within a unit. The individual component density failure rate is the number of components times the expected failure rated for that component type.

3.1.5 Display Characteristics

3.1.5.1 Brightness Variation.- Brightness variation, where referred to in this document shall be defined as:

$$\% \text{ Variation} = \frac{B\ Bright - B\ dim}{B\ Bright} \times 100\%$$

3.1.5.2 Line Width or Spot Size Variation.- These shall be defined as:

$$\% \text{ Variation} = \frac{S\ Large - S\ Small}{S\ Small} \times 100\%$$

3.2 Subsystems.- This section provides a brief general description of the ARTS II subsystems. These are:

(a) Decoding Data Acquisition Subsystem (DDAS)

(b) Data Processing Subsystem (DPS)

(c) Data Entry and Display Subsystem (DEDS)

Diagrams depicting the major subsystems are shown in figures 3.2-1 (TRACON) and 3.2-2 (TRACAB).

The subsystem shall accept data from radar sources, system input devices, and on-line interfaces; process the data as required to provide outputs to the controllers displays, to system output devices and for on-line data to appropriately equipped adjacent facilities. The design shall be capable of modular expansion. Such expansion may be in the form of hardware and/or computer programs defined in the contract as options for the initial system installation, or may be ordered later necessitating field installation after the system is in operation.

3.2.1 Decoding Data Acquisition Subsystem.- The DDAS receives broadband defruited or undefruited beacon video which is processed and transmitted to the DPS in the form of digital messages. Decoded analog data is also transmitted directly to the displays. The analog channel and decoder serve to provide backup if digital data is lost in a system failure. The beacon ground station equipment includes side lobe suppression, Mode C altitude interrogation and processing, and the generation of multiple mode interlace ratios. The airborne equipment (transponder) required for operation with the ground transmitter/receiver equipment is either the limited 64 code Mode 3/A type or the 4096 code Mode 3/A and C type. The detailed description of the DDAS is contained in Section 3.4.

3.2.2 Data Processing Subsystem.- The DPS is comprised of hardware and support software. Operational software shall be furnished by the Government, as specified in the contract schedule. The detailed description of the DPS is contained in Section 3.5.

3.2.2.1 Hardware.- The processor shall be an off-the-shelf mini-computer made up of functionally separate modules in the following categories:

(a) Computing

(b) Memory and Memory Management

(c) Input/Output

(d) Communication and peripheral equipment adapters

3.2.2.2 Support Software.- A comprehensive support software package shall be provided. It shall contain those programs necessary for program production, program debugging, system loading and data reduction and analysis, in addition to diagnostic and maintenance programs.

On-line software support programs shall be required for the purpose of minor program adjustments and system parameter revisions during operational use without system shutdown.

3.2.3 Data Entry and Display Subsystem.- The DEDS shall provide for the manual entry of data into the system and the receipt of display information from the DPS. The detailed description of the DEDS is contained in Section 3.6 of this specification.

3.2.3.1 Tower Cab Displays.- For a TRACAB or TRACON configuration, Digital BRITE displays will be supplied by the government.

3.2.3.2 IFR Room Displays.- For a TRACON configuration PPI displays will be provided by the contractor. The TRACON configuration must interface with the DBRITE equipment.

3.2.3.3 Input Devices and Controls.- Full alphanumeric keyboards including special function keys shall be provided for controller input to the system. Target identification may be accomplished by keyboard action or by use of a Positional Entry Module.

Display control panels shall also be provided for each display.

3.3 System Description and Features.- The ARTS IIA System consisting of the hardware described herein and the Government-furnished software described in the ARTS IIA Computer Program Functional Specification, NAS-MD-903, shall provide the following major functions:

(a) Scheduler and Executive Control

(b) Keyboard Input Processing

(c) Beacon Input Processing

(d) Beacon Tracking

(e) ARTCC/ARTS Interfacility Message Processing

(f) Bulk Store Flight Plan Input Processing

(g) Display Output Processing

(h) Minimum Safe Altitude Warning

(i) Conflict Alert/Mode-C Intruder

(j) System Monitor Processing

(k) Training Target Generator

(l) Data Extraction

(m) Data Reduction and Analysis

3.3.1 Scheduler and Executive Control.- The Scheduler and Executive Control function shall provide control of all subprograms. It shall meet the real-time demands of the system and cope with temporary overload conditions. Major function execution shall be scheduled on the basis of pre-established (prestored) priorities, and on the prestored execution frequencies desired. The executive function shall also contain precedence criteria which applies when some event must precede the execution of a function. Indication of the event is normally provided by an executive related interrupt.

3.3.1.1 On-Line File Manager.- The Scheduler and Executive Control shall provide an on-line file manager that shall exercise complete control of the Data Storage Subsystem (DSS). All requests for use of any DSS storage device shall be processed by the on-line file manager. The following functions shall be performed by the on-line file manager:

(a) Program Loading. - The DSU shall load the operational software from a reserved section of either Disc Drive as commanded from the programmers console or the System Monitor Console.

(b) Data Extraction. - The on-line file manager shall manage data extraction recording. This shall include message recording, automatic drive control, and archival recording.

(c) Program Patching. - The on-line file manager shall allow the installation of program patches through the DSS floppy disc drives.

(d) File Utilities. - Utilities shall be provided to move, copy, delete, and rename individual or multiple files, and to read and manipulate the file directory. These utilities shall allow movement of any file between any system device including the System Monitor Console.

3.3.1.1.1 Automatic Failure Recovery.- The Scheduler and Executive Control shall provide the capability to record critical system data and automatically recover from a system halt, software error, or transient hardware fault. Upon detection of any fault all hardware registers and memory shall be saved to the DSS, the system shall be reset, the operational program reloaded, critical data restored and the system restarted. The system shall be protected from repeated attempts to recover from a non recoverable error. The Automatic Recovery function shall be selectable thru keyboard entry and will default to a site adaptable selection at initialization.

3.3.2 Keyboard Input Processing.- The keyboard input function shall provide the primary controller-system interface. Keyboard messages shall be used to manually initiate and terminate control of tracks, to modify track data or track controller, to initiate and accept aircraft hand-offs, to reposition the presentation of A/N information, to enter data such as time and altimeter setting, and to request the printout or display of system data. Keyboard messages shall also control certain operational functions including ARTCC input, TTG, and Data Extraction.

3.3.3 Beacon Input Processing.- The Beacon Input Processing function shall be performed upon receipt of each DDAS interrupt. The DDAS interrupt is followed by input data--two words containing azimuth data, alarms and status, and two words for each target reply. Processing of this data shall be keyed to the DDAS interrupt in order to reduce processing time and minimize the memory storage requirements.

The target detection processing function shall operate on the digitized reply information from the DDAS and translate it into target report records. This function shall separate legitimate aircraft reply data from extraneous replies and determine the current aircraft position and pertinent target information for the target input function.

3.3.3.1 Target Input Processing.- The Target Input Processing function shall receive and process target data from the Data Acquisition Device Controller/Processor (DADCP) or the Mode-S/ASR-9 Line Adapter (MALA), detect DADCP and MALA errors and control selection of the proper input channel.

3.3.4 Beacon Tracking.- The Beacon Tracking function shall maintain the correct association between reports and the Flight Plan data identifying those targets. This shall be accomplished by scan-to-scan correlation. Other functions performed by Beacon Tracking shall include altitude tracking, automatic track acquisition, automatic track termination, and maintenance of track files for all declared tracks.

3.3.5 ARTCC/ARTS Interfacility Message Processing .- The ARTCC/ARTS IIA Interfacility with the National Airspace System (NAS) En Route (ARTCC) System shall provide ARTS IIA with Flight Plan information and the capability to perform track hand-offs between automated systems, including ARTCC's, ARTS IIIA's and ARTS IIA's.

3.3.6 Bulk Store Flight Plan Input.- The Bulk Store Flight Plan Input shall provide for input of prestored flight plan data from the Disc Storage Subsystem. The Flight Plan input capability shall be under operator control and may be used in place of the ARTCC Flight Plan input capability.

3.3.7 Display Processing.- The display output processing function shall prepare the alphanumeric display data for presentation on the controller's display. It shall format the data and refresh the displays via Display Device Controller Processor hardware.

Associated controlled (tracked) aircraft shall be displayed as Full Data Blocks (FDB's) containing aircraft identity, altitude, and ground speed. Inactive controlled aircraft shall be displayed in an Arrival/Departure list format that gives aircraft identification and various status codes. Targets that represent beacon-reporting aircraft not being controlled by any controller position shall be displayed as Limited Data Blocks (LDB's) or special single symbols. The display of system data shall include time, altimeter pressure setting, selected beacon codes, and computer memory read-out. Keyboard entries shall be displayed in the preview area; and if message entries contain errors, the illegal entry comment is displayed in the preview area. The PEM coordinate position shall be displayed as an alphanumeric character. Flight Plans and Alarm Data shall be displayed in separate tabular lists.

3.3.8 Minimum Safe Altitude Warning (MSAW).- MSAW shall generate an alert when associated Mode-C aircraft is at or predicted to be at an unsafe altitude. MSAW shall monitor aircraft terrain and obstacle separation and generate a controller alert via the ARTS II display and an aural alarm if an aircraft is below prescribed minimum.

MSAW logically separates into three monitoring elements:

(a) General terrain monitor

(b) Approach path monitor

(c) Satellite airport monitoring

3.3.9 Conflict Alert (CA).- The Conflict Alert function shall provide visual and aural alerts to controllers in the event associated Mode C aircraft are predicted to come in potentially hazardous proximity to, are currently in close proximity to, or are noted to be in a maneuver which could result in a potentially hazardous proximity to other associated Mode C aircraft. Special Full Data Block formats shall be used to indicate conflicts.

3.3.9.1 Mode-C Intruder.- The Mode-C Intruder function shall provide all Conflict Alert functions between all associated and non-associated Mode-C aircraft. Full and Limited Data block formats shall provide special Mode-C Intruder information to the controller.

3.3.10 System Monitor.- The operational software shall monitor the status of the system and provide messages to the System Monitor Console (SMC) as follows:

(a) Alarm printouts shall be requested by various functions as a result of program detected hardware or software malfunctions. The printouts shall provide an indication of system performance. Decisions regarding the impact of any malfunction, i.e., system usability, are left to the operator.

(b) Recording printouts shall be requested by the Keyboard Input processing function upon receipt of selected (supervisory) messages.

(c) Data printouts shall be requested by the operator (keyboard message) for indication of the current configuration.

The System Monitor function shall operate in the background mode of the SMC. All system monitor messages shall be displayed on the SMC monitor, printed on the SMC printer, and :omatically stored on a disc f. for later processing as selected by the operator. When the SMC is processing tasks in the foreground System Monitor messages shall automatically be displayed in a window on the SMC monitor, recorded in a disc file and printed. If the printer is busy, messages will be stored on a disc file and printed automatically at the termination of the foreground processing session.

3.3.11 Training Target Generator (TTG).- The integrated Training Target Generator shall provide the capability to generate and control simulated targets. The integrated training target generator shall operate in either of two modes: test mode or training mode. In the test mode, it shall generate simulated target reports to be used for the check-out and testing of an ARTS operational program. In the training mode, it shall generate simulated target reports in a mixed simulated/live environment to provide a controller training capability. Mode of operation shall be selected by a keyboard entry. An off-line Training Scenario Generator, operating on the SMC, shall provide for the generation of TTG scenarios.

3.3.12 Data Extraction.- The Data Extraction function shall provide the capability to extract information on-line from the ARTS IIA data base and record the data on the ARTS IIA Data Storage Subsystem. Filtering of data to be extracted shall be provided. Operator control of the Data Extraction function shall be provided by means of the display keyboard.

3.3.13 Data Reduction and Analysis (DR&A).- An off-line DR&A Editor function shall be provided for use with the ARTS II/ARTS IIA software support system. In addition the DR&A Editor shall operate on the System Monitor Console while the ARTS IIA Operational System is on line. The DR&A Editor shall read extraction messages recorded on the Data Storage Subsystem, filter the data as specified at start-up, edit the data in the message as required by the output message formats, and print the data. Each data class requested shall be listed separately. Page and data column headers shall be selectively printed at the top of each page, and scan end and summary statistics shall be provided.

3.4 DDAS Requirements.- This section specifies the requirements for the DDAS.

3.4.1 General.- The DDAS (Figure 3.4-1) shall consist of an Azimuth Range and Timing Group (ARTG), a Beacon Reply Group (BRG), a Display Video Generator (DVG), a Test Target Generator, an Azimuth Data Converter (ADC), an Acquisition Signal Conditioner (ASC), and an Output Buffer. The DDAS shall receive raw beacon reply video via either land line or radar microwave link remoting from the beacon receivers. The DDAS shall quantize the input video, decode the replies and generate reply messages in suitable form for compare processing by the Display Video Generator.

3.4.1.1 Range Unit.- The Range Unit portion of the ARTG shall provide subsystem clock data, range information, beacon mode decoding, and other synchronization timing and alarm signals, as required for operation of the BRG and logic circuits within other sections of the DDAS.

3.4.1.2 Beacon Reply Group.- The BRG shall receive and process beacon replies, extract the beacon reply information and prepare reply messages for further processing in the Display Video Generator (DVG).

3.4.1.3 Display Video Generator.- The DVG shall compare beacon codes and display controls, manually selected by an operator, display format (Section 3.4.6.) based on the comparison, for presentation on a PPI display.

3.4.1.4 Test Target Generator.- The Test Target Generator shall generate a real-time quality control test target reply, once each scan, for on-line maintenance, and maintenance test targets (selectable) for off-line maintenance.

3.4.1.5 Azimuth Data Converter _ The ADC shall convert one speed and ten speed synchro-positional information into digital azimuth change pulses (ACP's); and an Azimuth Reference Pulse (ARP).

3.4.1.6 Azimuth Unit.- The Azimuth Unit portion of the ARTG shall provide azimuth data to the Output Buffer for transmission to a data processor.

3.4.1.7 Output Buffer.- The Output Buffer shall provide reply data storage and interface the DDAS with the DPS.

3.4.1.8 Acquisition Signal Conditioner.- A duplexed ASC shall be provided as part of the DDAS. The ASC shall provide an interface for azimuth trigger and video information from the radar. For azimuth data, the ASC shall accept digital azimuth as defined by 3.4.2.4.3 or from the on-line ADC. Selection between inputs shall be by wire strapping. The ASC shall provide azimuths outputs to drive the ARTG of the DDAS, the DEDS displays, and other GFE equipment as required. The external equipments' output shall be defined by 3.4.2.4.1.2.1 and 3.4.2.4.1.2.2. For trigger and video, the ASC shall contain line compensation amplifiers for normal, MTI, and Beacon Video. The ASC shall also provide for separation of mixed video and triggers, and shall be capable of operation independent of ARTS IIA system operation. The ASC shall contain the capability by wire strapping, to select use of the extra trigger elimination circuit. The normal and MTI line compensation amplifiers shall accept video inputs as defined in Section 3.6.1.1.13, Condition 1, for compensated video: and Condition 2, for uncompensated video. The normal and MTI line compensation amplifiers shall perform as required by Section 3.6.1.1.14. The beacon line compensation amplifier shall accept inputs as defined by Section 3.4.2.5.2 and shall perform as defined by Section 3.4.2.5.5. The beacon line compensation amplifier shall provide outputs for the Beacon Reply Group and two sets of external outputs. The external outputs shall have the characteristics defined by Section 3.4.2.5.5.1 and 3.4.2.5.5.2. Selection between the dual channel ASC functions shall be by a switch on the DDAS. The dual channel ASC functioning shall be independent, such that any fault in one channel does not result in the loss of the remaining channel.

3.4.1.9 Associated Equipment.- The DDAS shall interface and operate with the following equipment.

(a) ATC Beacon, Ground Station, Type ATCBI-3, 4, 5 and Mode-S

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(b) Airport Surv...llance Radar, Type ASR-3, 4, 5, -, 7, 8 and 9

(c) Beacon Video Defruiting Equipment (Storage Tube and Digital) Type FA-7281 and MX-8757.

(d) Radar Microwave Link System, Type RML-1A, 2, 3, 4, and 6.

(e) Beacon Performance Monitor, Specification FAA-E-2271A.

(f) ARTS IIA DPS

(g) Displays:

1. ARTS II Display

2. BRITE 1, 2, 3, 4, and DBRITE.

(h) Video Mappers, FA-5450A, FA-5400, FA-5100A, FA-5450, FA-5100, FA-8049, GPA-131, AN/GPA-30, AN/GPA-91

<u>3.4.2 External Equipment Interfaces</u>.- The DDAS shall interface with the external equipment listed in 3.4.1. without any modification to the external equipments or degradation of their operation. The input circuitry of the DDAS shall provide the conditioning and isolation required to ensure proper operation of the DDAS. The input circuits shall bridge the input signals at high impedance (greater than 100 times the characteristic impedance of the input cable). Provisions shall be made to terminate the input cables with the proper termination impedance when required during equipment installation.

<u>3.4.2.1 Video Input Characteristics</u>.- Amplitude and phase compensated, or noncompensated beacon video, mode, and sync triggers will be received by the DDAS on a per sweep basis.

<u>3.4.2.2 Video Output Characteristics</u>.- The output of DDAS shall interface with the display equipments via the Display Video Generator. The cable distance from the DDAS to the displays shall be a maximum of 500 feet.

<u>3.4.2.3 Computer Interface</u>.- The DDAS shall include all the equipments required to interface with the computer. The computer interface shall be designed for operation over cable lengths of up to 150 feet.

<u>3.4.2.4 Antenna Position Information Interface</u>.- The DDAS shall be capable of either accepting conventional azimuth synchro data (1X and 10X) or digitized azimuth data from the output of an antenna mounted Azimuth Pulse Generator (APG). APG data will be per 3.4.2.4.1.2.

<u>3.4.2.4.1 Azimuth Synchro Data</u>.- The radar antenna azimuth data shall be translated to digital pulses by means of an Azimuth Data Converter. The ADC shall have a dual channel configuration which will be controlled by a switch on the DDAS. The input/output characteristics of this ADC as integrated in the overall system shall be as follows:

3.4.2.4.1.1 Input

(a) Reference Voltage: 110-125 volts RMS, 60 HZ AC

(b) Stator Voltage: 90 volts RMS nominal (max. output)

(c) System Type: One speed and 10 speed synchro transmitters

(d) Antenna Rotation Speed: 12 to 15 RPM

3.4.2.4.1.2 Outputs.- The ADC shall provide digital azimuth data to the Acquisition Signal Conditioner (ASC) which shall distribute the information to the DDAS, the DEDS, and other GFE equipment as required. The following defines the types of digital azimuth data outputs of the ASC:

3.4.2.4.1.2.1 Digital Data (75 ohms)

(a) Impedance (design center): 75 ohms

(b) Logic level "0": 0 to .5 volts D.C.

(c) Logic level "1": 5 ± 1 volts D.C. (positive going)

(d) Pulse width: 23 ± 3 microseconds

(e) Rise time: 1.0 microsecond (max.)

(f) Fall time: 1.0 microsecond (max.)

(g) Jitter: Azimuth Change Pulse ± 10 percent of nominal spacingAzimuth Reference Pulse ± 20 percent of ACP

(h) Azimuth change pulses: 4096 pulses per 360 of antenna rotation, equally spaced for constant rotation rate

(i) ARP position: At antenna north position midway between two ACP's.

3.4.2.4.1.2.2 Digital Data (600 ohms balanced line).-

(a) Impedance (design center): 600 ohms

(b) Azimuth change pulses (ACP): 4096 pulses per 360 of antenna rotation, equally spaced for constant rotation rate*

(c) ACP pulse to pulse jitter for constant antenna rotation rate: 10 percent of normal spacing*

(d) Azimuth reference pulse (ARP): One pulse of the same duration as are ACP per 360 of antenna rotation

(e) ARP position: At antenna North position, midway between two ACP's*

(f) ARP jitter: ± 20 percent of ACP nominal spacing*

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(g) Pulse amplit (ACP + ARP): 5V peak-to-peak 1V

(h) ACP and ARP wave form: Approximately sinusoidal

In addition, to its internal DDAS and RADS output, the ASC shall have two isolated outputs for each type of digital azimuth information. The ACP and ARP pulses shall be generated by separate independent circuits with each output consisting of an ACP output and an ARP output.

* Pulse spacing and jitter shall be measured at the 50 percent amplitude point, excluding overshoots, of the leading edge of each point.

3.4.2.4.2 Digital Azimuth Data.- The DDAS shall be capable of interfacing with both types of digital azimuth data as described in paragraph 3.4.2.4.1.

3.4.2.4.3 Azimuth Data Remoting.- The Government will employ two systems for transmission of the ASR APG data between the radar transmitter site, and the DDAS located in the TRACON operations building. For distance up to approximately 12,000 feet, ACP and ARP data will be transmitted over separate, shielded, and twisted pairs. In other cases, ACP data will be transmitted over the radar microwave link (RML) as listed in 3.4.1.1d.

The combined characteristics of the ADC and the ARTG input circuitry shall be such that all performance requirements specified herein are met when either land line or RML transmission of azimuth data is employed.

The DDAS shall interconnect with ATCBI-3, 4, and 5 systems and the ASR-9 System Communications Interface Processor (SCIP) and shall accept the reply pulses, triggers, and alarms generated for the indicator sites and process them as indicated in this specification.

3.4.2.5 Interface with SIF/ATCRBS Sensors.- The DDAS shall interconnect with ATCBI-3, 4, and 5 systems and the ASR-9 SCIP and shall accept the reply pulses, triggers, and alarms generated for the indicator sites and process them as indicated in this specification.

3.4.2.5.1 Beacon Video Remoting.- Beacon video and mode trigger pulses are transmitted by either land lines or Radar Microwave Link. The DDAS shall contain a Line Compensating Amplifier (3.4.2.5.5.) capable of interfacing with either transmission method and compensating the input signals when remoted by up to 12,000 feet of land line.

3.4.2.5.2 Beacon Video Inputs.- Uncompensated beacon video pulses, at the input to the DDAS, will have the following electrical characteristics:

(a) Amplitude: 1-7 volts*

(b) Rise time: 0.05-0.30 usec (measured between 90 percent and 10 percent amplitude levels)

(c) Fall time: 0.10-0.35 usec (measured between 90 percent and 10 percent amplitude levels)

(d) Pulse width: 0.20-0.70 usec. (half voltage points)

(e) Maximum noise level: 0.5 volts average peak

(f) D.C. baseline levels: 3.0 volts maximum

*NOTE: Under unusual circumstances, signal amplitudes may be as high as ± 50 volts. Although the DDAS shall not be required to operate at this voltage, voltage protection features shall be incorporated in the equipment to prevent damage from such abnormal signal levels.

3.4.2.5.3 Beacon Mode Signals.- The DDAS shall accept beacon mode pulses pair signals from the transmitter site equipment specified in paragraph 3.4.1.1. Uncompensated trigger signals shall have the following electrical characteristics as measured at the input of the DDAS.

(a) Amplitude: 10 to 60 volts

(b) Duration: 1.0 microsecond ± 0.5 (measured at the 50 percent amplitude points)

(c) Rise time: 10 percent to 50 percent of duration

(d) P1 to P3 pulse spacing: 8 microseconds ± 0.5 (mode 3/A) and 21 microseconds ± 0.5 (mode C)

3.4.2.5.4 Beacon Reply Characteristics.- Beacon reply characteristics will be specified in Appendix A. It should be noted, however, that the characteristics listed in Appendix A are for signals-in-space. Processing by Government-furnished ground remoting equipment will result in output characteristics as described in the referenced beacon equipment instruction books.

3.4.2.5.5 Line Compensation Amplifier (LCA).- The LCA shall be capable of accepting beacon video, mode, and sync triggers from either land line or Microwave Link (RML) equipment. If the land line interface is used, variable compensation adequate for any cable length from 200 to 12,000 feet shall be required to equalize the line and amplify the remoted video, mode triggers, and beacon sync trigger for transmission to the Range Unit. The mode triggers shall be separated from the video for use by the Range Unit and Beacon Reply Group, respectively. There shall also be three sets of isolated video and trigger signals available (via coax connectors or terminal board) for driving external equipment. Output signal characteristics shall be as specified in 3.4.2.5.5.1 and 3.4.2.5.5.2. The Line Compensating Amplifier (LCA) shall provide proper termination for Government furnished land line or radar microwave link remoting equipment by a wire strap adjustment or similar accessible means. The LCA shall also provide for separation of beacon trigger and video for either remoting technique. The beacon video input impedance shall be either:

(a) Greater than 7500 ohms resistive shunted by less than 250 pf. capacitive; or

(b) 75 ± 5 ohms resistive.

Either impedance shal. be provided by simple wiring ch..ge.

3.4.2.5.5.1 Compensated Beacon Video.- The characteristics of the beacon video out of the line compensator but prior to inputting to the Beacon Reply Group shall be as follows:

(a) Amplitude (Adjustable): 1-4 volts for any input level specified in 3.4.2.5.2.

(b) Rise time: 0.05 - 0.15 usec (measured between 90 percent and 10 percent amplitude levels)

(c) Fall time: 0.10 - 0.25 usec (measured between 90 percent and 10 percent amplitude levels)

(d) Pulse width. 0.35 - 0.60 usec (half voltage points)

(e) Maximum noi... level: 0.5 volts average peak

(f) Overshoot: Less than 10 percent

(g) Undershoot: Less than 10 percent

(h) Polarity: Positive

(i) DC level: Less than 0.05 volts

3.4.2.5.5.2 Compensated Mode and Sync Triggers.- The characteristics of the beacon mode and sync triggers out of the line compensator but prior to inputting to the Azimuth, Range and Timing Group shall be as follows:

(a) Amplitude: 25 to 60 volts

(b) Duration: 1.0 microsecond ± 0.5 (measured at the 50 percent amplitude points)

(c) Rise time: Less than 20 percent of duration

(d) Jitter: Less than 10 percent referenced to the input

(e) Polarity: Positive

(f) Waveform: Approximately a square pulse

3.4.2.6 Beacon Performance Monitor Inputs.- At those sites where the Government has provided a Beacon Performance Monitor (BPM), the indicator signals furnished to the DDAS shall be in accordance with Specification FAA-E-2261A. Alarm conditions sensed by the BPM shall be indicated by a switch closure grounding an input line to the DDAS. These alarms shall set a sensor alarm flag in the INITIAL message (3.4.5.).

3.4.3 Azimuth Range and Timing Group (ARTG).- The ARTG shall receive beacon system triggers (pre-triggers) directly from the line compensating amplifier and azimuth change and reference pulses from either an APG or the Azimuth Data Converter depending on the radar source equipment. This data shall be used by the ARTG to generate range and azimuth clock pulses and other timing and synchronizing pulses as are required by the logic circuits within the DDAS and DPS. The ARTG shall include provisions for decoding of externally-generated beacon mode interrogation triggers for internal system control. This group shall also provide the radar synchronizing trigger to the Fixed Map Unit (FMU). The ARTG shall utilize blanking signals from Government-furnished video mapping equipment (3.4.1.9) to inhibit video input to the DDAS. Internal monitoring of critical functions with appropriate alarms shall be provided. The ARTG shall provide a narrowband sensitivity test signal to the Acquisition Signal Conditioner (ASC). This signal shall occur at approximately beacon pretrigger time and at RTQC azimuth. This signal shall be used to trigger a remote beacon test set. The characteristics of this signal at the output of the ASC shall be as described in paragraph 3.4.2.5.5.2.

3.4.3.1 Azimuth Unit.- The azimuth unit shall accept 4096 equally-spaced Azimuth Change Pulses (ACP) plus one azimuth reference pulse (ARP) per each full rotation of the radar antenna. These pulses shall be generated by either the ADC or an APG (3.4.2.4). Design of the azimuth unit shall provide for operation with each of these inputs by means of an internal switch or simple wiring change.

3.4.3.1.1 Azimuth Counter.- A 12 bit counter shall be provided for counting the azimuth change pulses occurring each antenna scan. The counter shall be preset by the azimuth reference pulse to a predetermined count established to compensate for timing, misalignment of search and beacon antenna equipment, and beamsplitting bias. It shall be possible, by switch selection, to adjust the preset count of the counter, in increments of one ACP, to any count as required for test and alignment. Design of the azimuth unit shall include provisions for the addition of a second azimuth counter for future use in processing search radar data. Unused space shall be provided in the ARTG and reserved for this function. The second counter requirement may be eliminated provided the basic equipment design contains provisions for the alignment of search and beacon data.

3.4.3.1.2 Azimuth Unit Alarm.- Logic circuits shall be provided to monitor the performance of the azimuth unit. These circuits shall indicate failure of the azimuth change pulse and azimuth reference pulse inputs and the azimuth data counter. Alarm signals shall be available at a termination for use with external monitor equipment. An open circuit/ground type interface shall indicate these alarms for connection to external equipment.

3.4.3.2 Range Unit (RU).- The DDAS shall contain a Range Unit. The Range Unit shall receive a staggered or unstaggered radar pre-trigger or beacon synchronization trigger from the surveillance radar of the beacon system. This trigger shall initiate the range clock and the generation of all pulses that require synchronization with the search radar. Range information shall be established by a range counter which is initiated at pretrigger time and incremented by an internal oscillator. The range counter and its clocks shall be used to derive all timing and synchronization pulses required by the other logic circuits and functions of the DDAS. The Range Unit shall include provisions for decoding of externally generated beacon mode interrogation triggers for internal subsystem control. The Range Unit shall also provide a synchronization trigger to an external video mapper. The Range Unit shall accept a blanking signal from the video mapper to inhibit video input to the DDAS. Internal monitoring of critical functions with appropriate alarms shall be provided.

3.4.3.2.1 Range Counter.- Range clock pulses shall be counted in a single range counter so that the least significant bit of the counter represents 1/32 nautical mile. The contents of the counter shall be sampled and gated to other subsystem groups as required. The counter shall be capable of being preset at the time of the radar pre-trigger to the required value prior to zero range time to provide the required range reporting for a 60 nautical mile system.

3.4.3.2.2 Minimum Range Limiting.- The Range Unit shall provide a signal to inhibit processing of beacon data in the BRG and other logical sections as required from zero range to a predetermined range value. A second range inhibit signal shall be provided for connections to external equipment and further use by the Government to inhibit processing or radar data. The inhibit signal shall be manually adjustable in 1/16 nautical mile increments between 0 to 8 nautical miles. A minimum range limit function output signal shall be available for transfer to the output buffer. An output signal to a computer, via the output buffer, shall be provided when a minimum range limit function is selected. A second range inhibit signal shall be provided for connection to external equipment and further use by the Government to inhibit processing of radar data. The inhibit signal characteristics shall be three volts ± 1/2 volt in amplitude, 400 nanoseconds, ± 40 nanoseconds in width, and 120 ohm termination impedance.

3.4.3.2.3 Maximum Range Limiting.- The Range Unit shall provide a signal to inhibit the processing of beacon data in the BRG and other equipment groups, as required from a selected range to maximum range. The signal shall be manually adjustable in 1 nautical mile increments from zero range to maximum range. A second range inhibit signal, with signal characteristics as described in 3.4.3.2.2., shall be provided for connection to external equipment for future use in processing radar data.

3.4.3.2.4 Range Unit Monitoring.- Provisions shall be included to calibrate and monitor the performance of the Range Unit. Logic circuits shall monitor operation and indicate:

(a) Range clock out of tolerance (paragraph 3.4.3.2.1.). The allowable tolerance shall be ± 1/8 nautical mile at 60 nautical miles. Out-of-tolerance declaration shall be by comparison of an internal reference signal. External or externally derived signals shall not be used as references.

(b) Range counter failure.

(c) Beacon pre-trigger failure. A sampling window shall monitor the occurrence of pre-triggers at predetermined times depending on PRF. The received pre-trigger must fall within the window width otherwise an alarm condition shall be declared. The width of the window shall be adjustable by wire strapping or other similar accessible means in 1/8 nautical mile steps to a maximum of ± 2.0 nautical miles.

Alarm indications shall be provided to report a detected out-of-tolerance condition for the above and shall be reported to the data processor. An open circuit/ground type interface shall indicate these alarms for connection to external equipment. Maintenance indicators are described in paragraph 3.9.

3.4.3.2.5 Interrogation Mode Control.- The Range Unit shall accept mode signals for control of the processing of the beacon replies.

3.4.3.2.5.1 Mode Interface.- The DDAS shall be capable of operating with mode interlace patterns containing up to three modes in any interlace ratio. Processing of target replies is required only for Modes 3/A and C.

3.4.3.2.5.2 Mode Decoding.- The Range Unit shall include provisions for decoding of externally-generated beacon mode interrogation triggers for internal system control. The mode information shall be transferred to the BRG and DVG, as necessary. The mode information shall also be available for transfer to the output buffer.

3.4.4 Beacon Reply Group (BRG).- The DDAS shall contain a Beacon Reply Group (BRG), Figure 3.4-2. The function of the BRG shall be to accept the beacon pulse trains (replies) in serial form from the Line Compensating Amplifier and perform certain logical operations for each reply received on each beacon sweep. Upon entering the BRG, the video pulses shall be conditioned to DDAS levels, fed to a detector where the bracket pulses shall be sensed and the coded data sampled. The video shall be subject to inhibiting by an external suppression signal (video mapping blanking signal) which may occur during any portion of the pulse repetition period. Garble sensing, Special Position Identification (SPI) sensing, "X" pulse sensing and emergency detection shall also be accomplished in the BRG. Range data shall be received in the BRG from the Range Unit for use in conjunction with the decoded bracket pulses and any other requirements necessary to the BRG function. The BRG shall utilize its reply buffer registers for the temporary storage and accumulation of reply data. These registers shall be capable of accepting from the decoding delay circuitry reply codes as close as 800 nanoseconds apart. Reply data shall be held in these registers until it is determined if the target reply is garbled. The BRG shall be capable of processing up to two code trains within any 21.75 usec interval.

3.4.4.1 Functional Requirements.- The functions performed in the BRG shall be as follows:

(a) Video conditioning and suppression

(b) Bracket pulse detection

(c) Reply decoding (Modes 3/A and C)

(d) Data code garble sensing

(e) Quantized beacon video for external PPI display

(f) Single pulse slash (brackets) for external maintenance display

(g) Beacon test video input

(h) Detection of Code 7600, 7700, and 7500

(i) Special Position Identification (SPI) sensing

(j) Mode 3/A and C code transfer

(k) "X" pulse decoding and processing on Mode 3/A

(l) Rearranging of Mode 3/A data code.

(m) Rearranging of Mode C code (code conversion will occur in the computer).

(n) Minimum and maximum range blanking of beacon video.

<u>3.4.4.2 Video Conditioning</u>.- Upon entering the BRG, video signals shall first be examined to determine whether they meet the specified minimum amplitude requirements. The signals shall be accepted as legitimate reply pulses or rejected as noise according to the amplitude criteria established in paragraph 3.4.4.4.1. Signals meeting the acceptance criteria shall be designated as binary ONE's and shall be converted to the appropriate voltage level corresponding to machine logic. Signals not meeting the acceptance criteria shall be designated as binary ZERO, and the appropriate voltage level applied to it. Pulse widths of signals processed by the video conditioner shall remain unchanged. Following signal conditioning, the digitized output pulses shall be applied to a reply decoding circuit.

<u>3.4.4.2.1 Beacon Test Video Input</u>.- The input circuitry for video conditioning shall include an external jack for application of test signals.

<u>3.4.4.3 Beacon Video Suppression</u>.- Inhibit signals derived external to the BRG shall be used to suppress the processing of beacon data when they are present. Video processing shall be inhibited by the presence of either the beacon minimum or maximum range inhibit signals from the range unit. Range inhibit signals shall start at the predetermined values and be present during the period selected for each sweep.

<u>3.4.4.4 Reply Code Pulse Processing Requirements</u>.- The BRG shall accept beacon replies and quantize the data, using criteria specified in the following paragraphs.

<u>3.4.4.4.1 Reply Pulse Requirements</u>.- The BRG shall designate as a binary ONE any signal which exceeds the threshold setting. The BRG shall designate as a binary ZERO any signal which is below the threshold setting, or whose pulse width is below the minimum.

(a) Threshold Setting - A variable threshold shall be provided to control the acceptable data slice level. Any data that exceeds this threshold by 5 percent, shall be processed as a positive ONE. The threshold shall be adjustable from .5 to 1.5 volts.

(b) Pulse Width - Pulses with a width less than .15 usec (measured at the 50 percent amplitude) shall be designated a binary ZERO. The maximum pulse width of a single pulse is not expected to be greater than 600 nanoseconds; however, two replies may be superimposed so that a pulse received by the BRG may have an effective pulse width up to approximately 1.2 microseconds. To prevent loss of the second or super-imposed pulse, pulse width limiting circuitry shall not be used in the BRG.

<u>3.4.4.4.2 Framing Pulse Sensing Requirements</u>.- Two pulses whose leading edges are between 20.20 and 20.40 usec apart shall be sensed and defined by the BRG as a pair of framing pulses. Two pulses whose leading edges are separated by greater than 20.51 or less than 20.09 usec, shall be rejected by the BRG as being a valid pair of framing pulses. Pulses whose leading edges are separated by 20.09 to 20.20 or 20.40 to 20.51 usec, may or may not be, defined by the BRG as valid framing pulses. The bracket detection procedure implemented in the BRG shall be designed to recognize or reject pulse pairs with the separation specified above. The detection procedure shall not necessarily require leading edge detection.

<u>3.4.4.4.3 Reply Pulse Sampling Requirements</u>.- The sensing of a pair of framing pulses shall be sufficient indication that a reply has been received by the BRG. The sensing of a framing pair shall initiate the sampling of information pulses. The sampling procedure implemented in the BRG shall be designed to recognize pulses as defined below. The sampling shall not necessarily require leading edge detection:

(a) Information pulse taps on the decoding delay circuitry are to be strobed so as to process only pulses which have the characteristics described in paragraph 3.4.4.4.1. and whose leading edges occur during the interval between "n" (1.45) $\pm$ 0.10 usec with respect to the first framing pulse.

(b) Information pulses whose leading edges occur outside the interval defined by "n" (1.45) $\pm$ 0.21 usec with respect to the first bracket pulse shall be rejected. n = 1, 2, 3 ..... 13 (includes "X" pulse).

<u>3.4.4.4.3.1 SPI Sampling</u>.- The sampling procedure for the SPI shall be defined by both of the following statements:

(a) The SPI pulse shall be sampled so as to process all pulses which have the characteristics described in paragraph 3.4.4.4.1., and whose leading edge occurs during the intervals between 4.25 and 4.45 usec after the leading edge of the second framing pulses.

(b) Pulses whose leading edges occur outside the interval between 4.14 and 4.56 usec after the leading edge of the second framing pulse shall not be processed as SPI pulses.

3.4.4.4.4 Tolerance Variation.- Initially, many transponders may not maintain the tolerances specified in Appendix A; therefore, it shall be possible to make field adjustments in the BRG so that it will tolerate and accept bracket pulses and data pulses that are somewhat broader than the specified tolerances. Specifically, the pulse sampling tolerance in the BRG shall be dependent upon the basic frequency of operation and number of pulse positions utilized to accept data. To achieve the specified accept/reject criteria, all pulse sampling (both bracket and data pulse) shall be performed by accepting pulse leading edges in one of three adjacent acceptable positions. To adjust (relax) the tolerance requirements on sampling, the acceptable region shall be capable of expansion to five adjacent positions by wire straps, or similar means. This adjustment shall be possible on either bracket detection or code pulse sampling, or on both functions.

3.4.4.4.5 Bracket Pulse Detection.- Bracket pulse detection is the process of recognizing a pair of framing pulses in accordance with the requirements of paragraph 3.4.4.4.2. Occurrence of bracket detection shall establish the basic timing for information pulse sampling and garble sensing within the BRG. Bracket detection circuits shall detect beacon replies by sensing framing pulse pairs (F1 and F2) in the beacon video. Reply pulses from the video conditioning circuitry shall pass into a decoding delay circuit where individual pulses of the pulse train are stored to permit simultaneous detection of the framing pulses. This decoding circuit shall be tapped at intervals commensurate with the information pulse sampling requirements of 3.4.4.4.3. To prevent loss of replies during certain overlapped reply situations, leading edge detection techniques alone are not sufficient. Additional circuitry shall be provided to detect these situations and provide logic capable of performing bracket and pulse detection referenced to the trailing edge or equivalent, of the overlapped pulses.

3.4.4.4.6 SPI Replies.- Provision shall be made that if a reply received by the BRG contains an SPI pulse and an information pulse at pulse position C2, the BRG shall not indicate either a false bracket detection or a garbled reply and shall report the appropriate code and SPI information. Sampling the reply code data for an SPI pulse shall occur only upon recognition of a pair of framing pulses in the reply received.

3.4.4.4.7 Multiple Reply Sensing.- Replies transmitted from aircraft that are the same azimuth with respect to the site, and that are separated in slant range by less than 3.28 nautical miles, will be received by the BRG within a 40.6 usec period. Such replies can mutually interfere with each other in such a manner that pulses of one reply fall at legitimate pulse positions in the other reply. This condition shall be referred to as a garble. A second decoding delay circuit* (DL-2) shall be employed to provide a timing chain ($n \times 1.45 \pm 0.10$ usec, $n = 1, 2, 3 \ldots 15$) to store bracket pulse detection. Processing delay introduced by the BRG garble sensing logic shall not affect beacon code validation performed in the DPS or the range accuracy of the beacon report. A second reply received in the same 1/16 nautical mile range cell shall not be processed.

The following four relationships can occur in a two-reply pulse train when the F framing pulses of two replies are separated by at least 800 nanoseconds and not more than 40.6 microseconds.

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(a) Reply code pulses are overlapped; therefore, reply trains are interfering.

(b) Reply code pulses are interleaved; therefore, reply trains are non-interfering.

(c) Reply code trains are closely spaced and spatially interfering; therefore, a potential phantom reply(ies) exists.

(d) Reply code trains are closely spaced and spatially non-interfering.

Relationship (a) is a garbling condition which results in two detected reply code trains being mutually garbled. Relationships (b), (c), and (d) result in two detected reply code trains which, in the absence of a third reply, are correctly detected as ungarbled.

*NOTE: Not necessarily a delay line. While the delay line nomenclature has been used here in to designate the decode and degarbled functional logic, the contractor may use devices other than delay lines to perform these functions.

3.4.4.4.7.1 Interleaved Replies.- An interleaved reply condition shall exist when two replies are received and the pulses of one reply occur wholly within the time interval between the trailing edge and the leading edge of consecutive pulses of the other reply. When bracket detection of Reply A occurs, the bracket coincidence pulse shall be sent to DL-2, and the data strobed out of DL-1 and its information data strobed. Since Reply A bracket detection pulse does not occur at a tap on DL-2 simultaneous with the generation of bracket coincidence for Reply B, Reply A data shall be considered to be not garbled. Information data derived from Reply B shall also be retained for 21.5 usec to permit sensing of garbles which may be caused by a third train. If none exists, the data (Reply B) shall be transferred without garble indication.

3.4.4.4.7.2 Overlapped Non-Interleaved Replies.- An overlapped condition shall exist when replies are received such that the pulses of one reply overlap the pulse position of a second reply so as to permit them to be sensed at the occurrence of bracket detection of either reply. When bracket detection of Reply A occurs, its bracket coincidence pulse shall be sent to DL-2 and its information data strobed out of DL-1 and transferred to the BRG buffers. When bracket detection of Reply B occurs, its bracket coincidence pulse shall also be sent to DL-2. Since the bracket detection pulse of Reply A occurs at a tap on DL-2 simultaneously with the detection of bracket coincidence of Reply B, Replies A and B shall be considered garbled. Information data from Replies A and B shall be transferred with a garbled indicator. Garble sensing logic shall permit bracket detection to two or more replies, provided the leading edge of the F frame pulse in each reply is separated by at least 800 nanoseconds.

3.4.4.4.7.3 Closely-Spaced Replies.- Closely-spaced relies are two replies with the first framing pulse of each reply occurring between a nominal 20.65 and 40.6 usec apart. The BRG shall contain the necessary logic to recognize false (phantom) replies generated by the relative positions of the framing and information pulses of the real replies. Phantom replies will occur when an information pulse of Reply A is spaced so as to produce false bracket detection with the first framing pulse of Reply B and/or the second framing pulse of Reply A is space to produce false bracket detection with an information pulse of Reply B. In such a case, the phantom reply shall be destroyed and the closely-spaced replies (A and B) shall be reported ungarbled.

3.4.4.4.7.4 Mixed Reply Conditions.- Under certain circumstances, three or more beacon replies may be received and the relationship between such replies will result in any combination of interleaved, overlapped, and closely-spaced replies. The BRG shall contain logic to prevent false garble indications, and to prevent the removal of the garble indicator from the reply or replies which are in a garble condition for mixed replies received from up to three aircraft.

3.4.4.5 Application of Bracket Pulse Detection.- Upon detection of framing pairs for each reply received for each mode of the selected interrogation mode interleave pattern, a single bracket decode pulse shall be generated for use in BRG garble sensing logic. A bracket pulse output shall also be provided for external use as specified in paragraph 3.4.8.

3.4.4.6 Data Code Processing.- Prior to, or during transfer of, reply code data from the BRG, the relative position of the individual code pulses with the respect to one another shall be changed to provide the formats specified below.

3.4.4.6.1. Data Code Transformation.- The change of relative positions of the code bits shall be referred to as transformation and shall be performed on each type of reply, as described below:

(a) Mode 3/A - The interleaved pulse groups CA and BD shall be transformed to non-interleaved groups of A-B-C-D.

(b) Mode C - The interleaved pulse groups CA and BD shall be transformed to non-interleaved pulse groups of D-A-B-C.

3.4.4.6.2 Special Military Replies.- Some military transponders indicate EMERGENCY and IDENT conditions by a reply format different from that previously described. These special military replies are defined and shall be processed in accordance with subparagraphs hereunder.

3.4.4.6.2.1 Military IDENT.- In lieu of the single SPI pulse following the second framing pulse (F2) by 4.35 ± 0.1 microsecond, the complete code train occupying, with the first framing pulse (F1) of the second code train is repeated, the SPI pulse position of the first code train. This reply shall be recognized as an IDENT reply and only the first reply, with an SPI indication, shall be processed.

3.4.4.6.2.2 Military EMERGENCY.- In lieu of the single code 7700 reply, four reply pulse trains are transmitted, with the first framing pulse (F1) of each reply train occupying the SPI pulse position of the preceding pulse train. The first pulse train will consist of a 7700 code, with the succeeding trains blank (000). These replies shall be recognized as an EMERGENCY, and only the first reply train, with an EMERGENCY indication, shall be processed.

3.4.4.6.3 SPI Pulse.- The SPI shall be sensed and processed as specified in paragraph 3.4.4.3.1. The BRG shall perform no logical operations on the SPI pulse other than decoding and transferring it for further processing.

3.4.4.6.4 "X" Pulse.- The "X" pulse shall be sensed and processed as specified in paragraph 3.4.4.4.3. The BRG shall perform no logical operations on the "X" pulse other than decoding and transferring it for further processing. The capability of inhibiting the display of a selected target code when the "X" pulse is detected shall be included. (Refer to 3.4.6., Display Video Generator). The use or non-use of this capability shall be selectable by wirestrap.

3.4.5 Output Buffer.- The DDAS shall contain the necessary interface logic to connect the DDAS to external data processing equipments. The output buffer shall be designed, manufactured and delivered to interface with an ARTS IIA DPS as specified in paragraph 3.5. The output buffer shall transmit one sync message, one INITIAL message, plus up to 30 beacon REPLY messages to the processor per beacon sweep. The output format characteristics are described in Figure 3.4.5-1. Provision shall be made in the DPS output buffer circuits to insert one odd party bit with every 8-bit byte transferred to the computer.

3.4.5.1 Independent Operation.- The DDAS shall be capable of providing beacon decoding and display generation capabilities of the basic configuration to the operational displays independent of any failure of the ADC, Azimuth Unit, Output Buffer, or external processors. No manual intervention or switching shall be required to maintain a full beacon display capability when failure of either of these devices occur. It shall be possible to perform maintenance on the failed unit without interference to the decoding capability.

3.4.5.2 Beacon Data Overload.- The DDAS shall include an alarm circuit to indicate loss of data during a sweep due to overload of the information code buffers. When an overload occurs, an overload bit shall be set in the INITIAL message of the next sweep; an alarm signal shall also be provided to an external circuit. An overload bit shall also be provided to an external circuit. An overload bit shall be set whenever replies have been lost during a certain sweep due to total buffer occupancy caused by either closely-spaced aircraft or DDAS interface hang-up. The overload alarm shall be set and reset for each sweep.

3.4.5.3 Aircraft Traffic Density Distribution and Processing Rate - The DDAS shall be capable of preparing INITIAL and REPLY message transfers when the subsystem is operating in an air traffic control environment which will contain wide variations in traffic density and distribution. It shall be assumed that the total number of transponder-equipped aircraft in the beacon antenna coverage pattern will not exceed 256 per scan. It shall be further assumed that up to 30 aircraft replies are received within the beamwidth of the antenna. The maximum density in any 45 degree sector will be 100 true targets. The DDAS shall be capable of preparing REPLY messages in response to all beacon replies received at a rate of up to 30 valid replies per beamwidth which are distributed as follows:

(a) A closely-spaced sequence of non-overlapping or non-interleaved replies.

(b) At least two overlapped or interleaved replies.

(c) At least two overlapped or interleaved replies followed by another reply which is separated from the two replies by at least 21.5 usec; time is measured between the last pulse of the overlapped for interleaved pair and the first pulse other reply.

Under the conditions where traffic exceeds the limits specified above, no errors shall be introduced into reply messages that are produced by the DDAS during a traffic overload condition, and no errors shall be produced or data lost when the overload condition is terminated. The overload alarm flag shall be prepared for transfer to the DPS when a traffic overload exists.

3.4.5.4 Time Delay.- All reply messages for each beacon interrogation sweep shall be transferred to a data processor prior to the next beacon sync trigger.

3.4.6 Display Video Generator (DVG).- The Display Video Generator (DVG) shall identify, by distinct video symbology on an operational-type display, aircraft which are transmitting selected codes. Provision shall be made to recognize up to 10 selected Mode 3/A code blocks and three special codes. The DVG shall be wired to provide video outputs for up to eleven individually controlled displays. The actual output capability, however, shall be limited to the total number of displays supplied. Controls for selection of codes, and the specific format on the display, are specified below. Code comparison shall be performed after garbled logic processing.

3.4.6.1 Code Selection Box.- There shall be one code select box whereby ten selected beacon codes may be entered. These codes shall be supplied to the DVG for code comparison with the incoming beacon video. The box front panel layout shall be similar to Figure 3.4-3. The code switches shall be backlighted, thumbwheel-type switches.

3.4.6.1.1 Special Function Channel.- Channel 1 on the code select box (upper left - Figure 3.4-3) shall be designated as a special function channel 3.4.6.2.1.). The faceplate shall be marked to distinguish this channel from the others.

3.4.6.1.2 Emergency Alarm.- Visual and audible alarm indicators shall be activated when an emergency, communication failure, or special code is detected ungarbled for a predetermined number of replies. The detection criteria shall be wirestrap adjustable from M = 2 to 7 replies out of a total of N = 3 to 8 replies. A momentary switch shall be provided to reset the alarm for a period adjustable between 30 seconds and 3 minutes. If the condition causing the alarm persists, or a new emergency is sensed at the end of the reset period, the alarm shall again be energized.

3.4.6.1.3 Physical Characteristics.- The code select box shall be mountable in the vertical or near vertical panel of an existing console. Maintenance of the code select box shall be performed from the front side of the mounting panel. Cabling shall enter the box from the rear via a cable connector. The box shall be designed so that the physical dimensions do not exceed 12 inches in length and 10 inches in width and 6 1/2 inches in depth.

3.4.6.2 Display Control Panel.- There shall be a single display control panel located with each display. The display control panel shall control the type of display format used on its associated display. The display control panel front panel layout shall be similar to Figure 3.4-4. Each box shall have 12 switches. The function of these switches is specified in the following paragraphs. All switches on the display control box shall be backlighted. A backlighted, Plexiglas strip shall be provided beside the code display selection switches. The strip shall provide for manually writing the codes set into the code select box on the display control panel. A special marking shall indicate the special functional characteristics of Channel 1.

3.4.6.2.1 Selectable Codes.- The display control panel shall enable the use of the codes entered on the code select box. Ten three-position (ID-SEL-OFF) switches shall be provided, each corresponding to the similarly positioned code on the code select box. The ten three-position switches shall operate in conjunction with the two-position (C/S-OFF) Common-System switch to govern the format generated on the display. The Common-System switch shall exhibit control over the ten three-position code selection switches as follows: With the Common-System switch in the C/S position.

(a) OFF Position - All beacon targets shall be displayed by a single slash.

(b) SEL Position - All beacon targets shall be displayed by a single slash.

(c) ID Position - All beacon targets on that display having the selected code shall be displayed as a double slash except targets having the code of Channel 1 which, when selected, shall display a triple slash. A target with a selected code, responding with an SPI identifier, shall be displayed as a single bar (bloomer), except targets having the code of Channel 1 which shall be displayed as a single bar and slash. All other beacon targets in the Common-System shall be displayed as a single slash. With the Common-System switch in the OFF position:

(1) OFF Position - All beacon targets shall be inhibited.

(2) SEL Position - All beacon targets on that display having the selected codes shall be displayed as a single slash. A target that responds with the SPI identifier shall be displayed as a single bar (bloomer). No other targets shall be displayed.

(3) ID Position - All beacon targets on that display having the selected code shall be displayed as double slash, except targets having the code of Channel 1 which, when selected shall be displayed as a triple slash. A target that responds with the SPI identifier shall be displayed as a single bar (bloomer), except targets having the code of Channel 1 which shall be displayed as a single bar and a slash. No other targets shall be displayed.

3.4.6.2.2 Special Codes.- The analog decoder shall recognize three special beacon codes and generate unique display symbols for these codes independent of the display control box switch settings. The three special codes and their unique display symbols are specified below:

(a) 7700 Reply - The emergency code, 7700, when received, shall cause a double bar (double bloomer) to appear on all displays.

(b) 7600 Reply - The radio communication failure code, 7600, when received, shall cause a filled-in double bar (wide bloomer) to appear on all displays.

(c) 7500 Reply - The 7500 code, when received, shall cause a double slash, followed by a bloomer, to appear on all displays.

Means shall be provided to have the 7500 code changeable to any other non-discrete code by means of a wire strap selection.

3.4.6.2.2.1 Military ID and Emergency.- Military ID and Emergency (3.4.4.6.2.1, 3.4.4.6.2.2) shall be displayed in the same manner as described in paragraph 3.4.6.2.1. and 3.4.6.2.2.

3.4.6.2.3 Raw Video.- The display control box shall have an additional three-position (Mode 3A-OFF-MODE C) switch used to select the display of the received video. The raw video used for display shall be derived from immediately after the BRG's beacon video quantizer. With the raw video switch in the Mode 3A position, only Mode 3A replies are displayed. Similarly, in the Mode C position, only Mode C replies will be displayed. The selection of raw video shall override the generation of code selected video formats and the incoming beacon video shall be presented to the display.

3.4.6.2.4 Physical Characteristics.- The display control panel shall be designed to be as small as practical, not to exceed 8 inches long, 7 inches wide, and 6 1/2 inches deep, to be mountable in either a vertical or near vertical panel of an existing console, or to be used as a table-top device. Table-top mounting shall be used with display positions not having convenient vertical-mounting facilities. When vertical-mounting is utilized, maintenance shall be performed from the front side of the mounting panel and the cabling shall enter the box from the rear via a cable connector.

3.4.6.3 Display Format.- The DVG shall generate seven unique display patterns, as illustrated in Figure 3.4-5. When Mode 3/A and Mode C interlacing are used, the display video generator shall inhibit the generation of Mode C targets and it shall generate patterns from the Mode 3/A targets in the sweep immediately preceding the Mode C sweep. The characteristics of these patterns shall be as follows.

3.4.6.3.1 Single Slash.- The single slash shall be a pulse corresponding to the range of the received reply. The range positioning of the DVG outputs to the display shall be identical for all displays. An adjustment shall be provided, by wire-strapping or other similar accessible means, to vary the position of the slash ± 2 nautical miles in range, independent of the real time adjustment of beacon pre-trigger and range counter preset. The pulse width of the single slash shall be 0.83 ± 0.1 microseconds.

3.4.6.3.2 Double Slash.- The double slash shall be the single slash followed by a second slash. The spacing between slashes shall be a basic parameter used in generating all the other patterns on that display. It shall be capable of being adjusted to one of three values as a function of the display's range selection switch to approximate constant spacing on the display regardless of the range selected. Provision shall be made for selection of one of seven spacing values. These values shall be 2.48, 4.14, 5.80, 8.28, 9.94, 11.60, and 13.25 microseconds or the nearest spacing equivalent to these values achievable using multiples of 0.829 micro-seconds, selection of the spacing shall be controlled by three lines from the display. Activation of the selected line shall be by a contract closure. The pulse width of the second slash shall be 0.83 + 0.1 microseconds.

3.4.6.3.3 Triple Slash.- The triple slash shall be the double slash followed by a third slash. The spacing between slashes shall be a basic parameter used in generating all the other patterns on that display. It shall be capable of being adjusted to one of three values as a function of the display's range selection switch to approximate constant spacing on the display regardless of the range selected. Provision shall be made for selection of one of seven spacing values. These values shall be 2.48, 4.14, 5.80, 8.28, 9.94, 11.60, and 13.25 microseconds. Selection of the spacing shall be controlled by three lines from the display. Activation of the selected line shall be by a contact closure. The pulse width of the third slash shall be 0.8 ± 0.1 microseconds.

3.4.6.3.4 Bloomer.- The bloomer shall be generated by the filling of the space between the double slash. The pulse width of the bloomer shall follow the double slash spacing as a function of the display's range selection switch.

3.4.6.3.5 Double Bloomer.- The double bloomer shall be the single bloomer followed by a second bloomer. The space between bloomers shall be approximately equal to the width of a bloomer.

3.4.6.3.6 Wide Bloomer.- The wide bloomer shall be generated by the filling in of the space between the double bloomer.

3.4.6.3.7 Double Slash, Bloomer.- The double slash bloomer shall be a double slash followed by a bloomer.

3.4.6.3.8 Bloomer Slash.- The bloomer slash, a combination of an SPI bloomer and the triple slash function, shall be generated by filling of the space between the first and second slash of the triple slash. The pulse width of the bloomer shall follow the spacing of the first and second slash as a function of the display's range selection switch.

3.4.6.4 Display Output Interface.- The DVG output signals shall have the following characteristics as measured at the output of 500 foot cable terminated in 75 ohms:

(a) Polarity: Positive

(b) Amplitude: 2.0 to 5.0 volts adjustable

(c) Rise Time: 0.1 microsecond max.

(d) Fall Time: 0.2 microsecond max.

(e) Impedance: 75 ± 5 ohms

(f) Cable Type: RG-59A/U or equivalent

3.4.7 Test Target Generator (TTG).- The DDAS shall contain a test target generator (TTG). The test target generator shall generate a real time quality control (RTQC) reply once each antenna scan, and shall generate maintenance test targets for off-line maintenance. The real time quality control target shall be generated once each scan to occur in the 55 nautical mile range cell or beyond with an azimuth extent (width) of 64 ACP's, starting at 180 degrees. A beacon video mask shall be generated around the RTQC test target and be placed in a position which will not interfere with normal ATC operations. This mask shall be used to inhibit beacon video in the area of the RTQC test target. A switch shall be provided to permit a RTQC target code of all "zeros" or all "ones" (a 7777 code). The necessary decoding logic shall be provided to permit the test target and the mask to be generated at the proper time. At the appropriate decode, a pulse shall be entered into a shift register which is clocked at the Beacon Reply Group clock rate. A bit counter shall enable "ones" to be generated at the F1 and F2 pulse positions and either "ones" or zeros to be generated for the A, B, C, D, or X pulses. The resulting code train shall be inserted into the beacon quantizer input while all other video is inhibited by the beacon video mask.

The maintenance test targets shall check tolerances on bracket detection and code sampling, as well as various code patterns, including 7700, 7600, 7777, and 0000. In addition, the test target generator shall have the capability of generating military ident, two code trains, and military emergency, four code trains. These maintenance test targets shall be generated at 32 nautical miles range and be 16 targets equally spaced with an azimuth extent (width) of 64 ACP's, starting at 0 degrees azimuth. The maintenance test targets shall be displayed on the DEDS. When the maintenance test targets are displayed, live beacon video shall be inhibited.

3.4.8 Beacon Remote Control Box.- A remote control box shall be located near an operation position in the IFR/operations room in the TRACON configuration. In the TRACAB configuration, the remote control box shall be located near an operating position in the tower cab. This control box shall have maximum dimensions of 10" X 12" X 5 1/2" (including knobs and connectors) when used with ATCBI-3B interrogator equipment and a maximum dimension of 5" X 6" X 5 1/2" when used with an ATCBI-4, 5.

The controls on each control box are as follows:

3.4.8.1 ATCBI-3B

3.4.8.1.1 Controls

(a) Power ON-OFF

(b) Interrogator Channel Select

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(c) Local Enable (a momentary contact switch which allows transfer of control to the interrogator site)

(d) Interrogate ON-OFF

(e) Defruiter ON-OFF

(f) Buzzer Mute

3.4.8.1.2 Indicators

(a) Interrogation Mode (3/A, C)

(b) Range Error

(c) No Control

(d) Interrogate

(e) Defruiter ON

(d) Monitor Fail

(g) Alarm (Flashing Light and Audible Buzzer)

(h) Interrogator Power ON

The function of controls "a" through "d" shall be identical to corresponding ATCBI-3B Indicator Site Equipment controls. Control "e", when in the ON position, shall supply a ground to a remote line which will place the defruiter in the beacon reply video path. In the OFF position, the ground is removed and the defruiter is bypassed. Control "f" shall be a momentary control switch whose function is to silence the audible alarm indicator for a period adjustable between 30 seconds and three minutes. If the condition causing the alarm persists, or if a new alarm is sensed at the end of this silenced period, the audible alarm shall again be energized. Indicator lights "b" through "e" shall be energized by readback signals (ground) from the interrogator site, and shall be identical in function to existing ATCBI-3B indicators. Indicator "a" shall include individual mode indicator lights for Modes 3/A and C, which shall be energized by sensing of the appropriate mode trigger pair. Indicator "f" shall be energized upon application of a ground from the interrogator site performance monitor. Indicators "b" and "f", when energized, shall flash ON and OFF at a rate of ON one second, OFF one second, and shall also energize the audible alarm "g." Indicator "h" shall be energized upon application of a readback signal (ground) from the interrogator site.

(a) ATCBI-4, 5

(1) Controls

(a) Defruiter ON-OFF

(b) Buzzer Mute

(2) Indicators

(a) Interrogation Mode (3/A, C)

(b) Defruiter ON

(c) Monitor Fail

(d) Alarm (Flashing Light and Audible Buzzer)

Controls and indicators shall perform functionally in the same manner as for the ATCBI-3B control box described above.

<u>3.5 Data Processing Subsystem</u>.- The data processing subsystem shall consist of hardware and software as follows:

(a) Central Processing Module (CPM)

(b) Memory Management Unit (MMU)

(c) Memory Module (MM)

(d) I/O Channels

(e) Peripheral Adapters and Control Modules (PAM)

(f) Peripheral Equipment

(g) Memory Power System

(h) Support Software, including Maintenance and Diagnostic Software

The ARTS IIA DPS shall be a Computer Automation LSI2/40 or equivalent and shall be compatible with the ARTS II DPS. It may be composed of as many modules as necessary to perform the tasks required by this specification with the restriction that the basic ARTS IIA system in both the TRACAB and TRACON configurations shall contain only one CPM. The basic DPS hardware shall be an off-the-shelf, general purpose, solid-state, stored program mini-computer which is modular and readily expandable. Unless otherwise specifically noted here, all DPS capabilities described shall be supplied with the basic system.

<u>3.5.1 Central Processing Module</u>.- The ARTS IIA Central Processing Module shall be comprised of a processor module, memory management unit module, memory module, memory power system, and a bus extension. These shall be housed in a chassis assembly physically identical to that used for the ARTS II CPM.

The ARTS IIA CPM shall be physically interchangeable with the ARTS II CPM. No changes in existing cables and no additional power shall be required.

The ARTS IIA CPM shall have a 16-bit word format an instruction set divided into seven major classes which provide memory-to-register and register-to-register data movement as well as conditional jump, single and double-register shift, register change, machine control and Input/Output instructions. The computer shall utilize eight addressing modes for effective and efficient management of memory resources. The ARTS IIA CPM shall be upward compatible with the ARTS II CPM and shall provide increased processing and memory capabilities.

The computer shall contain random-access integrated circuit memory operating typically at a 0.5 microsecond memory cycle time. As configured, the computer chassis shall contain 256K memory words and a memory management unit with high speed cache memory. Since this system contains volatile IC memory, an uninterruptable power source shall be required. The computer shall accommodate additional memory, and shall have the capability for expansion to 4 megawords.

<u>3.5.1.1 ARTS IIA Processor</u>.- The ARTS IIA processor shall have the following characteristics:

(a) Parallel processing of full 16-bit words and 8-bit bytes

(b) Seven (3 software accessible) 16-bit hardware registers, one 8-bit status register

(c) Memory word addressable as a full 16-bit word or as two separate 8-bit bytes

(d) Computer clock time shall be 100 nanoseconds maximum

(e) Direct memory access provides data transfer rates up to 645,160 words per second

(f) Binary 2's complement arithmetic processing

(g) Hardware multiply and divide

(h) ROM instruction decode architecture

(i) Signal bus structure facilitating ease of additional I/O expansion

(j) Functionally identical to the ARTS II processor

<u>3.5.1.1.1 Instruction Set</u>.- The ARTS IIA processor shall provide an instruction set divided into seven classes. The instruction set of the ARTS IIA processor shall be identical to that of the ARTS II processor, with execution times a minimum of 1.9 times faster. The instruction classes are:

(a) <u>Memory Reference</u>.- Access memory in either full word or byte mode and perform logical and arithmetic operations involving data in memory and data in hardware registers. The hardware multiply, divide, and normalize instructions are included in the class.

(b) <u>Byte Immediate</u>.- Similar to memory reference in that they perform logical and arithmetic operations involving data in hardware registers. The operand data, however, is contained within the instruction word so that it is immediately available for processing without requiring an operand cycle to fetch it from memory.

(c) Conditional Jump.- Test conditions within the computer and perform conditional branches depending on the results of the tests performed. Jump may be as much as +64, -63 locations from the location of the conditional jump instruction.

(d) Shift.- Include single-register logical, arithmetic, and rotate shifts; double register logical and rotate shifts.

(e) Register Change.- Provide logical manipulation of data within hardware registers.

(f) Control.- Enable and disable interrupts, suppress status, control word or byte mode data processing, and perform other general control functions.

(g) Input/Output.- Provide communications between the computer and external devices. They include conventional I/O instructions plus block transfer and automatic input/output instructions. I/O may be to/from register or directly to/from memory.

3.5.1.1.2 Memory Addressing.- The ARTS IIA processor shall access full 16-bit words and 8-bit bytes (half words) in memory. Instructions which access memory may operate in either word or byte mode. Memory reference instructions shall be 16-bits in length (one-word instructions), with the eight least-significant bits plus three control bits dedicated to memory addressing. The eight least-significant bits address 256 words or bytes. The computer shall use the three control bits to specify several addressing modes. These addressing modes are discussed briefly as follows:

(a) Scratchpad.- Scratchpad addressing accesses the first 256 words in memory in Word Mode, or the first 256 bytes in Byte Mode. The first 256 words in memory are referred to as "Scratchpad" memory, because these are common words which can be addressed directly by instructions located anywhere in memory. With MMU (see paragraph 3.5.1.2.1.) map translation off scratchpad is physical memory address 0 to 256. With map translation on, scratchpad shall be the first 256 locations (page 0) of the map. The ARTS IIA system shall be implemented with scratchpad mapped to physical address 0 to 256 for all maps.

(b) Relative.- In Word Mode, relative addressing shall address an area of memory extending from the instruction address forward 256 words (+256) or backward 255 words (-255). In Byte Mode, the range is forward 512 bytes. Bytes shall not be directly addressed relative backward.

(c) Indexed.- The Index register may be added to the address field of memory reference instructions to form an effective memory word or byte address.

(d) Indirect.- Indirect addressing shall use scratchpad or relative addressing to access word in memory which contains the address of a memory operand. The word that contains a memory address rather than a operand is called an address pointer. In Word Mode, multi-level

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indirect addressing shall be possible; i.e., one address pointer may contain the address of another address pointer rather than the address of an operand. In Byte Mode, only one level of indirect addressing shall be possible.

Indirect addressing may also be used in conjunction with indexing. When indexed indirect addressing is specified, the indirect operation shall be performed first and then the contents of the index register are added to the contents of the address pointer.

3.5.1.1.3 I/O Structure.- The ARTS IIA processor shall have a parallel I/O structure that shall provide both ease of interfacing and powerful peripheral control. The I/O structure shall provide:

(a) Vectored Interrupt.- The ARTS IIA processor shall provide vectored hardware interrupts, wherein each peripheral controller supplies its own unique interrupt address to any location in memory. There are five standard interrupt levels; two internal and three external. Internal interrupts shall consist of the Power Fail interrupt and the Console interrupt. External interrupts may be invoked on three externally accessible signal bus lines. The priority level of these interrupts is in descending order with Power Fail the highest priority. The third external level with daisy chain priority control lines shall accommodate an unlimited number of vectored interrupts.

(b) Parallel Buses.- Separate buses shall be provided for device address selection, data transfer, control signals, and interrupt signals.

3.5.1.1.3.1 I/O Modes.- I/O operations shall be performed utilizing the various I/O modes described as follows:

(a) Direct Memory Access (DMA).- The parallel bus architecture shall provide Direct Memory Access thereby making possible the presentation of alphanumeric display during dead time and the input data from the Decoding Data Acquisition Subsystem during beacon sweep time.

(b) Block Input/Output.- The Block I/O feature of the computer shall enable the computer to transfer data blocks of any length at a very high rate. Data is exchanged directly between the memory and the peripheral interface controller.

(c) Programmed Input/Output via Processor (PDC).- A Programmed Data Channel capability shall be provided by the processor for handling data that must be examined immediately upon input or is the result of computations that must be output immediately. Programmed I/O via the processor inputs data directly to or from the operating registers of the computer.

(d) Programmed Input/Output via Memory.- This capability shall permit the transfer of data to and from memory without disrupting the working registers of the computer. Any size block of data may be transferred into or out of memory at any address.

(e) Automatic Input/Output under Interrupt Control (DMC).- A Direct Memory Control (DMC) capability shall be realized in the processor through the device initiated use of the Automatic I/O instruction. The characteristics of this capability shall be as described in item d except for the vectored entry that occurs upon interrupt by the device.

3.5.1.1.3.2 I/O Transfer Rates.- The ARTS IIA processor shall have minimum I/O transfer rates as follows:

Summary of I/O Transfer Rates

DMA	645,160 w/s	
Block In	467,289 w/s	
Block Out	416,666 w/s	
PDC In (Processor)	140,845 w/b/s	w/s = words/second
PDC Out (Processor)	142,857 w/b/s	b/s = bytes/second
Programmed In (Memory)	104,166 w/b/s	w/b/s = words or bytes/second
Programmed Out (Memory)	107,526 w/b/s	
DMC In	96,154 w/b/s	
DMC Out	92,238 w/b/s	

3.5.1.1.4 Power Failure Protect.- A power failure protection feature shall be provided such that when the input voltage falls below a given level, the system shall protect itself from damage and shall prevent loss or alteration of system data. When normal power levels have returned, previously stored data shall be displayed and all functions shall be available to the controller within 30 seconds after resumption of power. Power recovery shall be automatic and, if multiple power supplies are used, shall be insensitive to primary power phases employed in the respective power supplies. A power failure shall not result in the loss of any data stored in memory, hardware registers, or peripheral storage devices prior to power failure.

3.5.1.1.5 Real Time Clock.- The DPS shall have a 1 day real time clock. The clock shall operate by incrementing a hardware or memory register at a fixed rate of 60 times per second or faster. The clock shall be under software control and shall have the capability to interrupt the DPS after a specified period time has elapsed.

3.5.1.1.6 System Monitor Console Interface.- The computer shall be interfaced to a System Monitor Console as described in 3.5.2.1. This shall be a fully buffered interface and will accommodate nine user selectable data transmission rates ranging from 75 to 9600 bits per second. Either half or full-duplex operation shall be selectable on command. The interface controller shall be configured to provide for half duplex EIA RS-232B interface using ASCII X 3.4 format between the System Monitor Console and the computer. The following characteristics shall be selectable:

(a) Parity - Odd, even, or none (even parity selected)

(b) Frame Size - 5, 6, 7, or 8-bits and 1, or 2 stop bits (8-bits and stop bit selected)

(c) Baud Rates - 75, 110, 134.5, 150, 300, 600, 1200, 4800, and 9600.

In addition, the capability for transmitter-to-receiver back-to-back diagnostic looping under program control shall be provided.

3.5.1.1.7 Autoload.- The Autoload feature shall consist of a Read-Only Memory (ROM) programmed with a complete binary loader which shall be capable of loading binary programs from several input devices. The Autoload hardware reads from the ROM when the AUTO switch is activated.

In addition, the Autoload ROM shall include the necessary firmware program to allow all locations in memory to be read to the Data Storage Subsystem, upon manual initiation, in the event of a system fault.

3.5.1.1.8 Computer Control Display Console.- The computer shall be provided with a front panel console. The console shall provide the switches and indicators required to operate, display, and control the computer. All console switches, except the Console Enable switch shall be momentary contact touch switches and all indicators shall be light-emitting diodes (LED's). The console shall interface to the computer via a private console bus, plus special lines direct to the computer, to provide operational control of the computer for the performance of certain tasks such as stop, step, start, register read, register write, and autoload. Most actions taken by the operator cause an interrupt signal to be sent to the computer. To prevent inadvertent console operations during normal operational use or during period of unattended operation, manual operation of the console shall be disabled by a console switch.

3.5.1.2 Memory Management Unit.- The Memory Management Unit shall expand the direct memory addressing capability of the ARTS IIA processor by providing a page-oriented translation table that will allow memory access up to 4 megawords, by converting the processors' 15-bit logical address into a 22-bit physical address. The MMU shall also contain a 1K word high speed cache memory to reduce average memory access time and increase processor thru-put.

3.5.1.2.1 Memory Translation.- The primary function of the Memory Management Unit shall be the translation of the 15-bit logical address supplied by the processor into the 22-bit physical address required by a 4 megaword memory subsystem. To accomplish the 15-bit to 22-bit address translation, the MMU shall be configured around a page-oriented translation table. This translation table, which shall consist of a 1K word RAM array, is internally divided into sixteen directories or MAPs (also referred to as user numbers). Each directory (MAP) provides 32 words (pointers), with each word acting as the translation medium for a 1K word memory block referred to as a PAGE.

Structuring the translation table in this manner provides each of the 16 directories with a full 32K of memory address capability. Therefore, since each directory word performs address translation on a 1K word block of logical addresses, a processor generated reference to a page of logical address locations may be mapped to any 1K block of physical memory. Furthermore, since the MMU is designed to output a 22-bit translated address, in response to each 15-bit logical address, the 1K page being referenced may be located anywhere within the 4 megaword memory system.

3.5.1.2.2 Cache Memory.- The Memory Management Unit shall contain a 1K word, 16-bit high speed 50 nsec cache memory system to enhance thru-put of the ARTS IIA processor. To accomplish this memory enhancement function, the cache shall contain a copy of the memory locations of its most recently accessed pages. Should a second, or successive, read be performed on a memory location currently duplicated within the cache and the page address matches that contained in the cache, then, the requested data shall be returned to the processor from the cache rather than from memory. The actual cache "hit" rate to be realized by the ARTS IIA will be program dependent.

3.5.1.2.3 Split Chassis.- To accomplish the task of address translation within the 4-megaword address range, the MMU shall be installed in a split motherboard chassis. A specially designed split 9-card motherboard shall permit the MMU to be placed between memory address and control source lines, and the memory itself. This interruption of the control lines shall allow the MMU to exercise control over memory addressing as well as to control the actual memory cycle enabling and timing signals.

3.5.1.3 Memory Module.- The ARTS IIA memory module shall be an error correcting random access semiconductor memory and shall provide 256K 16-bit words of storage. It shall keep soft errors from accumulating by performing error correction during the refresh cycles required by the dynamic semiconductor memory chips. A 5-bit error code and associated logic shall correct all single bit errors and detect double bit errors. The ARTS IIA semiconductor memory module with error correction and 22-bit addressing shall interface with the Memory Management Unit.

3.5.1.3.1 Cycle Time.- The memory cycle time shall be such that all functional requirements of this specification are met but in no event shall a complete read/write cycle be greater than 750 nsec. The bidder shall clearly indicate cycle time in the proposal.

3.5.1.3.2 Memory Modularity.- The ARTS IIA memory shall be expandable in increments of 256K words to a maximum of 2M words within the DPS chassis. It shall be possible to expand memory size in the field with a maximum of 30 minute system down time. The bidder shall indicate what size memory shall be supplied and what expansion capabilities are provided.

3.5.1.3.3 Memory Power Supply.- The ARTS IIA Memory Power Supply is a separate battery backup power supply that shall allow the ARTS IIA memory to retain data throughout a primary power disruption lasting a maximum of 15 minutes when the batteries are fully charged. The maximum transfer time from utility power to battery-supplied power shall be 10 msec maximum. The output voltage holdup time shall be 20 msec minimum after input power removal. The Memory Power Supply batteries shall be sealed, maintenance free, and have a minimum life expectancy of 3 years. Status indicators shall be provided to indicate the state of charge on the batteries. The Memory Power Supply shall be located within the ARTS IIA cabinet if possible. An externally mounted Memory Power Supply shall require approval of the Government.

3.5.1.4 Internal Interfaces.- The DPS shall interface with other ARTS IIA subsystems as described below:

3.5.1.4.1 Data Acquisition Subsystem Interface.- The DDAS shall interface to the DPS through a Data Acquisition Device Controller Processor. Output messages from the DDAS are defined in Figure 3.4.5-1. The DADCP shall include sufficient processing and memory capacity to perform Beacon Target detection processing as described in 3.3.3 on the beacon replies from the DDAS and provide target reports to the DPS. The DADCP shall be capable of performing target detection on 30 transponder replies per sweep and produce 256 target reports per scan. The DADCP/DPS interface shall have a data transfer rate sufficient to transfer 256 target reports per scan. The target detection algorithm to be performed by the DADCP is defined in the ARTS IIA Computer Functional Specification NAS-MD-903.

3.5.1.4.2 Display Subsystem Interface.- The DEDS or DBRITE shall be interfaced to the DPS through a Display Device Controller Processor (DDCP). The system shall provide for the simultaneous operation of 11 displays and 22 data entry sets. Each display shall be capable of accommodating two associated data entry sets.

Each display and its associated DDCP shall be interfaced to the DPS. Where more than one data entry set is associated with a display, these may be operated over a common channel if such operation does not effect the speed of entry or limit their operation in any other way.

The DDCP shall receive display data from the DPS, process as required, and independently refresh the interfaced display at the refresh rate defined in 3.6.1.3.

The DDCP shall contain sufficient processing capacity and memory to provide all data management functions required to refresh the displays and maintain communication with the DPS. The DDCP shall operate at a load of less than 50% of processor and memory capacity for the display model described in Figure 3.6-2. and less than 90% of processor and memory capacity for the video compression display model described in Figure 3.7.5-1.

3.5.1.4.3 Aural Alarm.- The Aural Alarm shall provide a separately actuated aural alarm for each controller's display. The aural alarm at each display shall be actuated whenever the operational software declares an alert at that display. The duration of the aural alert shall be determined by hardware and shall be identical for all displays. Each alert shall be able to be actuated or deactuated without disturbing or effecting other alerts in progress. An alert shall be able to terminated by software before the hardware time-out has expired. The Aural Alarm Computer Interface shall interface the CPM with up to two aural alarm control units.

3.5.1.4.3.1 Aural Alarm Control Unit.- When activated for a specific display, the Aural Alarm Control Unit (AACU) shall generate a 450 Hz $\pm$ 50 Hz tone that is interrupted at a 5 Hz $\pm$ 1 Hz rate. The interrupted tone shall be generated continuously at the specified display until deactivated by an internal hardware time-out or the computer interface. Each AACU shall be able to operate separately and in any combination up to six speakers. The AACU shall have front panel mounted test control indicators and a single volume control. A minimum volume control shall be located within the AACU accessible for maintenance adjustment only. The AACU shall be surface mountable and shall be located up to 500 feet from the DPS. The remote speakers shall be wall or console mountable or shall stand independently on self contained rubber feet, and shall be located up to 500 feet from the AACU.

3.5.1.5 External Interfaces.

3.5.1.5.1 Peripheral Equipment Interfaces.- The DPS shall be capable of interfacing with the following peripheral equipment:

(a) System Monitor Console

(b) Data Storage Subsystem

(c) Communications devices

Adapter modules for the above shall be readily available off-the-shelf items or included with the basic CPM.

3.5.1.5.2 Communications Interfaces.- The DPS shall be capable of interfacing with a modem adapter capable of operating 2400 BPS full duplex

3.5.1.5.2.1 Interfacility Modem Interfaces and Adapter.- The high speed Modem Adapter (MA) shall function as a full duplex interface between the I/O channel and the NAS Interfacility Data Set (IFDS) as specified for Type III terminal equipment in FAA-E-2217 with Amendment 4 and Specification Change 2. Both input and output between memory (via the MA) and the modem shall independently and simultaneously operate at a data rate of 2400 bits per second. In addition, the adapter shall process control words and generate and transfer status interrupt words without interference to the data flow. The MA transfers data to the modem, serially (parity first then most significant bit) at 2400 bits per second. The adapter transfers data to the CPM 8 data bits, parallel in request-acknowledge sequence. The MA operates under control of the CPM in four modes - send disable, send enable, receive disable, and receive enable. Send disable inhibits data transfer from CPM to the modem, send enable provides data transfer from the CPM to the modem and receive enable, provides data transfer from the modem to the CPM.

3.5.1.5.2.1.1 Data Format.- A Data Byte shall be 8 bits plus odd parity with parity bit transmitted first followed by the most significant bit and the least significant bit last.

3.5.1.5.2.1.2 Device Interfaces.- The MA interfaces with the modem via send data, send clock, receive data, receive clock, and data set alarm lines. This interface transfers data at the rate of the modem controlled Send/Receive clock. Data is transferred, in descending order, parity first, then bits 7 through 0. The signal on the Send Clock and Receive Clock lines is initiated by the modem and is used to gate data from the Send Data Line to the modem (transmitter) and to gate data from the modem (receiver) to the Receive Data line. These clock signals are presented by the modem at all times, at 2400 cps rate, without regard to data being present. A Data Set Alarm Line permit the MA to sense modem alarm status.

3.5.1.5.2.1.3 Commands.- The MA functions simultaneously and independently in the Send mode and Receive mode and is controlled by the CPM through four mode control commands. These commands are - Send Disable, Send Enable, Receive

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Disable, and Receive Enable. The MA responds to enable mode commands by enabling the requested mode immediately upon receipt of the command. The MA responds to a disable mode command only when actively transferring a character in the requested mode. If the MA is actively transferring a character in the requested mode, the command is retained and responded to when the transfer is complete. While Send is disabled, the MA disables data transfer from CPM to modem transmitter and generates and transfers an idle code, alternate one-zero pattern, to the modem transmitter. The MA disables Send when one of the following conditions occur:

(a) Application of input power

(b) Input power decreased to a critical level.

(c) A Disable Send command is received from the CPM.

(d) The MA interrupts from CPM with an Output Timing Error status.

Send remains disabled until the MA receives an Enable Send Command from the CPM. While Send is enabled, the MA enables data transfer from CPM to modem transmitter. After receipt of an Enabled Send command from the CPM the MA terminates generation and transfers one sync code to the modem transmitter and proceeds as described under Data Transfer. While Receive is disabled, the MA disables data transfer from modem receiver to CPM. The MA disables Receive when one of the following conditions occur:

(a) Application of input power

b) Input power decreases to a critical level

(c) A Disable Receive command is received from the CPM

(d) An Input Timing Error occurs

Receive remains disabled until the MA receives an Enable Receive command from the CPM. While Receive is enabled, the MA searches for a sync code from the modem receiver. When the sync code has been recognized, data is transferred from the modem to the CPM as described below until a valid ECM is detected. When EOM is detected, data transfer is inhibited, and the MA resumes searching for a sync code.

3.5.1.5.2.1.3 Data Transfer.- The MA transfers data between the CPM and modem, at a modem controlled clock rate of 2,400 bits per second. The MA transfers data, from CPM to modem while Send is enabled. After the transfer of the Sync code to the modem, the MA is ready to accept data from the CPM. It then sends a data request. The CPM detects the request signal. The CPM responds, in accordance with internal priority, by loading data on the output lines and acknowledging this request. The MA detects the acknowledge. The MA responds by sensing the output data and drops the request. The output data is processed by the MA for transfer to the modem. The MA again takes a request in normal data transfer operations until the CPM terminates data transfer operations by transferring a Disable Send command to the MA. The MA processes data received from the CPM for transfer to the modem by:

(a) Checking parity in each data byte.

(b) Sampling longitudinal parity in data and entering the results into the MA LRC Send Register.

(c) Searching for a LRC Prepare code in data. After a LRC Prepare code has been detected, it is then routed followed by the contents cleared from the MA LRC Send Register through further processing for transfer to the modem.

(d) Serializing parallel data.

The MA transfers data, from modem to CPM while Receive is enabled and after the sync code is recognized. The general sequence of events in transferring data from IFDS to the CPM is as follows:

(a) The MA loads the input data lines with a data word.

(b) The MA sends on input request to indicate that a data word is on lines.

(c) The CPM detects request. The CPM responds, in accordance with internal priority, by sensing the data sending an acknowledge signal.

(d) The MA detects acknowledge and responds by clearing the request.

The preceding sequence is repeated in normal data transfer operations until an EOM code is received from the MA. The MA processes data received from the modem for transfer to the CPM by:

(a) Assembling serial data into a parallel form.

(b) Checking parity in each data Byte.

(c) Checking longitudinal parity in data.

(d) Searching for an EOM code.

<u>3.5.1.5.2.1.4 Status Information</u>.- As a result of a unique event, the MA interrupts the CPM with a status code indicating the occurrence of that event. These events/status are described as follows:

(a) The MA checks parity in all data bytes transferred from CPM to MA. If a parity error is detected, the MA interrupts the CPM with an Output Byte Parity Error status. The MA corrects the parity of the Byte in error, complements the LRC register, and continues transmission in the normal manner. (Any subsequent Byte parity errors will not recomplement the LRC Register).

(b) The MA checks Byte parity in all data transferred from the modem to MA. If a parity error is detected, the MA corrects parity and transmits an Input Lateral Parity Error status word to the CPM. Data transfer from the modem to the CPM continues. Each time an input parity error is detected, the MA transmits a parity alarm signal pulse to the modem.

(c) The CPM must respond within 3 milliseconds with an acknowledge to an output request from the MA. If the CPM fails to do this, the MA interrupts the CPM with an Output Timing Error status, transmits 9 zeros to the IFDS, and disables Send.

(d) The CPM must respond within 3 milliseconds with an acknowledge to an input request from the MA. If the CPM fails to do this, the MA interrupts the CPM with Input Timing Error status, and disables the Receive mode.

(e) The MA samples longitudinal parity in data transferred from modems to CPM and enters the results into the MA LRC Receive Register. The MA searches for a LRC Prepare code in data transferred from the modem to CPM. The MA after detecting a LRC Prepare code byte, transfers the byte to the CPM and compares the next byte, (contents of the ARTCC LRC Register) and transfers the half-added sum to the CPM. The contents are then cleared and the process is repeated. If both contents do not compare, the CPM is presented with an LRC Error Status and continues until receipt of EOM.

(f) While transferring data from the modem to the CPM, the MA searches for an End of Message (EOM) code. After an EOM code has been detected, the MA transfers the EOM code to the CPM, interrupts the CPM with an End of Message Detected Status, and resumes searching for a sync code from the IFDS.

(g) When the MA detects a sync code, while receive is enabled, the MA interrupts the CPM with sync status.

(h) When the IFDS switches from the "no alarm" to the "alarm" condition, the MA interrupts the CPM with Data Set Alarm status. Subsequent status interrupts also contain this status as long as the modem is in the alarm state.

(i) All 256 data codes are available for data characters except the two codes assigned for LRC prepare and End of Message. The LRC prepare code is 10110011. The EOM code is 10110001.

(j) The sync pattern is seventeen or eighteen zeros followed by a one. On transmission, it is seventeen zeros followed by a one, but on reception, since the last idle code bit may have been a zero, it may contain seventeen or eighteen zeros. Nineteen or more zeros followed by a one shall not be considered a sync code.

(k) The interface shall be per MIL-STD-188c paragraph 7.2.1. through 7.2.1.8.1.

<u>3.5.1.5.3 Mode-S/ASR-9 Interface</u>.— The DPS shall be capable of interfacing with the Mode-S/ASR-9 surveillance systems. The Mode-S/ASR-9 interface to the ARTS IIA shall consist of two redundant data channels. Each channel shall consist of three digital data links. The interface shall be implemented with a Mode-S/ASR-9 Line Adapter (MALA). The MALA shall be designed to use the signal

and data format protocols as defined in the Mode-S/ASR-9 Interface Control Document. The MALA shall be designed to mount in the DPS chassis and shall interface to the DPS Data Bus. Each MALA shall interface to one data channel of three digital data links. Each MALA shall consist of one printed wiring board. Two MALAs shall be provided.

3.5.2 Peripheral Equipment.- The following I/O devices shall be available as off-the-shelf equipment and shall be delivered as a part of the DPS subsystem.

3.5.2.1 System Monitor Console.- A System Monitor Console (SMC) shall be provided with each system. The SMC shall interface to the DPS through the TTY interface port on the CPM at 9600 bits per second minimum. The SMC shall consist of a commercial off-the-shelf microcomputer including a minimum 12 inch diagonal video display, one 1.2 megabyte 5 1/4 inch and one 1.44 megabyte 3 1/2 inch floppy disc drives, a 20 megabyte or larger fixed disc drive with self parking heads, a 2400 bit per second internal modem and a 300 character per second wide carriage printer with a minimum of 132 print columns. The SMC shall mount in a separate stand that shall accommodate all SMC equipment and shall be no larger than 30" wide by 30" deep by 42" high. A commercial off-the-shelf operating system including system utilities, a compiler and other software as needed for operating the SMC shall be provided. The SMC shall have sufficient processing and memory capacity to perform simultaneously the System Monitor and Data Reduction and Analysis functions described in paragraph 3.3.

3.5.2.2 Data Storage Subsystem.- The Data Storage Subsystem (DSS) shall provide all the data storage requirements for the ARTS IIA system. The Data Storage Subsystem shall consist of the following units:

(a) Mass Storage Unit

(b) Data Backup Unit

(c) Data Transfer Unit

The Mass Storage Unit shall be mounted in a single assembly and shall reside in the same cabinet as the DPS. A separate on/off power switch shall be provided to control all power to the cabinet mounted DSS. The Data Back Up Unit and/or the Data Transfer Unit may be incorporated into the System Monitor Console or mounted in the Data Storage System with the Mass Storage Unit. The interface to the DPS shall mount in the DPS chassis.

3.5.2.2.1 Mass Storage Unit.- The Mass Storage Unit shall consist of two standard off-the-shelf fixed media disc drives each with the following minimum characteristics:

(a) Formatted Capacity - 160 Megabytes

(b) Data Transfer Rate - 1.5 Megabytes per second

(c) Track-to-track access - 4 msec.

(d) Track access - 28 msec. average

(e) Self parking heads

Each disc drive in the Mass Storage Unit shall be independently addressable from the DPS.

3.5.2.2.2 Data Backup Unit.- The Data Backup Unit (DBU) shall consist of a standard off-the-shelf magnetic tape cartridge drive with the following characteristics:

(a) Capacity - 100 Megabytes

(b) Data transfer rate - 50 Kilobytes per second

The Data Backup Unit shall operate independently of the DPS so that DPS resources are not used during data transfer.

3.5.2.2.3 Data Transfer Unit.- The Data Transfer Unit (DTU) shall consist of two standard off-the-shelf floppy disc drives capable of being formatted in a standard format compatible with the ARTS IIA DPS and the DOS support system.

3.5.3 Utility Software.- A comprehensive utility software package shall be provided. All utility software shall operate on a separate support software development system. The bidder in the proposal shall clearly indicate the various levels of utility software available and the development system required to operate at those levels.

3.5.3.1 Assembler.- One symbolic assembler shall allow the use of meaningful symbols to represent absolute values. It shall eliminate the need to maintain detailed records such as absolute memory assignments for instructions and data. It shall provide the flexibility of optionally allowing programs to be assembled relative to zero with the absolute addresses assigned at load time. It shall also provided the capability for individually assembled program modules to communicate with one another at execution time. The language shall consist of instruction mnemonics, pseudo operations, assembly directives, macro commands, symbols, operators, and a set of rules by which these items are combined to produce an assembly language source program.

The source program shall be written on an assembly language coding form and then transferred via a CRT editor to a computer input medium such as magnetic tape, disc, or punched cards. At program assembly time, a listing shall be produced containing all the information necessary for efficient program debugging. In addition, the object code shall be output on a medium such as punched cards, magnetic tape, or disc at the option of the programmer to provide the code that will be the input to the loader program at execution time.

The symbolic assembler shall provide the following features:

(a) One or two pass assemblies.

(b) Programmer defined mnemonics.

(c) Nested macro capability.

(d) Standard subroutine linkage.

(e) Relocatable object code.

(f) Comprehensive error flags.

(g) Side-by-side source and object code listing.

(h) Line ID's suitable for editorial reference.

The symbolic assembler concordance program shall generate an alphabetic list of all symbols found within a given program with a statement number reference to every occurrence of each symbol in the program. Symbol definitions shall be differentiated from references and information shall be provided as to whether a symbol is external, local, undefined or multi-defined.

3.5.3.2 Additional Utility Software.

(a) A program capable of: duplicating object files, listing any or all file records, deleting any selected file records, modifying any selected file records, adding file records to an existing file and sorting file records.

(b) A program loader capable of loading both absolute and relocatable code. The loader shall be capable of linking together independently assembled programs. The loader shall operate using the peripheral equipment supplied with the basic system. The loader shall also have the provision of accepting programs at load time on fixed or floppy disc.

The contractor shall provide any additional commercially-proven support software which might be of use. Such software will be exempt from testing and documentation requirements as specified elsewhere in this specification. Documentation quantities and delivery dates shall be in conformance with that required for other support software.

3.5.3.3 On-Line Utility Software.- On-Line utility software shall be provided which will allow software personnel to inspect and make changes to memory while the ARTS IIA system is simultaneously performing an on-going ATC function.

3.5.3.4 Bulk Flight Plan File Editor.- A program to allow the operator to inspect, modify, add and delete files on the bulk flight plan files on the DSS using the ARTS IIA System Monitor Console on line shall be provided.

3.6 Data Entry and Display Subsystem (DEDS).- The Data Entry and Display Subsystem shall provide for the composite display of broadband beacon/radar video, computer generated alphanumeric data and shall provide the means for data entries to the Data Processing Subsystem.

Two basic subsystem types will be utilized in fulfilling the individual site requirements. The TRACON configuration will consist of PPI displays which time-share broadband radar/beacon video with computer generated alphanumeric data. The TRACAB configuration will consist of three GFE DBRITE display subsystems. The overall subsystem layouts for each configuration are shown in

Figures 3.2-1 and 3.2-2.

3.6.1 TRACON Configuration Description.- The TRACON display is to be a radar display console with radar processing units, alphanumeric generation unit, field select circuitry, data entry devices, and interface circuitry required to refresh the display from the ARTS IIA DPS. It shall be completely contained in a single, stand-alone console assembly except for the keyboard and PEM which shall be a separate package connected to the console by means of a flexible cable.

The radar/alphanumeric display console herein specified shall include the following basic functional elements:

(a) 22" CRT and deflection system
(b) Radar video circuitry
(c) Radar sweep generator
(d) Range mark generator
(e) Computer I/O interface
(f) A/N character generator
(g) Leader generator
(h) Radar/AN time share switching
(i) Data Entry devices
(j) Radar and A/N controls
(k) Compass Rose

This display console shall be capable of accepting radar normal and MTI video, radar pretrigger, and radar antenna positional data from the DDAS Acquisition Signal Conditioner (ASC). It shall also accept map and beacon video inputs. The display shall interface with the DPS and shall be operated in the working air traffic control environment. The radar/alpha-numeric display and data entry block diagram is shown in Figure 3.6-1.

3.6.1.1 Radar - PPI Performance Requirements.- This section provides the detailed requirements for the presentation of analog radar data.

3.6.1.1.1 CRT.- The display console shall incorporate a Plan Position Indicator (PPI) with a cathode ray tube (CRT) size of 22-inches as required by the contract schedule. The minimum usable display diameter shall be 20 inches (22-inch CRT). The 22-inch CRT shall be in conformance with FAA-E-2512 and shall have phosphor mixture specified in FAA-E-2512 and shall have electrostatic focusing with electromagnetic deflection.

3.6.1.1.2 Deflection System.- The PPI shall use fixed-coil deflection for principal sweep and shall incorporate a precision two-axis magnetic yoke. Each axis of the deflection coil shall be driven by a direct-coupled, push-pull feedback amplifier. The frequency response, power capability, linearity, recovery time, and any other pertinent characteristics of the complete deflection system shall be such as to produce results in accordance with all requirements specified herein. In addition, the deflection system shall be capable of 99.9 percent recovery from full scale deflection in less than 20 microseconds.

3.6.1.1.3 Sweep Rotation.- The PPI sweep shall be synchronized with the radar antenna azimuthal position, with rotation in a clockwise direction. The nominal antenna rotation rate will be 15 revolutions per minute (RPM); however, the display equipment shall meet all performance requirements for any antenna rotation rate from 4 to 20 RPM. The display equipment shall accept azimuth change pulses (3.6.1.1.12) as the data source for antenna position.

<u>3.6.1.1.4 Sweep Ranges and Decentering</u>.- Sweep range of six (6), ten (10), twenty (20), thirty (30) and sixty (60) nautical miles shall be provided. In addition, a continuously variable range from less than six (6) to at least sixty (60) nautical miles shall be provided. Ranges shall be selected by means of a console front panel range selector switch. An unused wafer, with contacts for each fixed range, shall also be included on the range selector switch. The range selector switch shall indicate the range selected. A separate continuously variable front panel control shall be provided to establish the displayed range when the variable range is selected. The ranges shall be in the following sequence as the range selector switch is rotated in a clockwise direction: Six (6), ten (10), twenty (20), thirty (30), sixty (60) and variable.

It shall be possible to position the sweep origin at any point on the usable face of the CRT: i.e., to off center the display in any direction up to one radius, by means of two console front panel controls (East-West and North-South). In any off-centered condition up to one radius the sweep lengths shall be sufficient to cover the scope face and shall retain the sweep linearity requirements of 3.6.1.1.5.1, except that the range need not exceed a maximum of 60 nautical miles. With the sweeps adjusted to the nominal ranges, range marks shall be displayed in the off-centered position at least up to 12 nautical miles on the 6 nautical mile range, 20 nautical miles on the 10 nautical mile range, 40 nautical miles on the 20 nautical mile range, and up to 60 miles on the 30, 60 nautical miles and variable ranges. A front panel two-position switch shall provide for normal centering and decentering. There shall be no discernible interaction on the PPI display between the normal centering and decentering circuits, and the selection of normal center shall always return the sweep origin to the same center position. There shall be no noticeable drifts of sweep start with time in off-centered positions. In the normal centering position, console front panel controls shall be provided of sufficient range to center the display. The stability of normal centering shall be such as not to require readjustment of these controls more frequently than daily. All four front panel centering and decentering controls shall be press-to-engage type of controls. These controls shall disengage under spring tension when released, leaving the precise settings intact until further readjusted. Circuitry shall be incorporated to sense the condition where the CRT beam would be deflected beyond the usable face of the CRT. Upon sensing such a condition, the beam current shall be cut off until the beam has been positioned for the next item to be drawn on the usable face of the CRT.

Each of the range scales specified shall be adjustable in length by ± 20 percent by maintenance controls while maintaining full coverage of the CRT, except that the maximum range of 60 nautical miles need not be exceeded.

<u>3.6.1.1.5 Sweep Generating Equipment</u>.- The PPI console shall include sweep and CRT unblanking gates for all ranges specified in 3.6.1.1.4. The stability of the sweep origin shall remain within a circle no greater than one-tenth inch in diameter in both the centered and decentered mode over the entire range of the service conditions. Provisions shall be incorporated in the

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sweep generating equipment to permit adjustment of sweep start and video unblanking to be coincident with ASR zero range with the use of a pretrigger from 20 to at least 150 microseconds ahead of the main radar transmitter pulse (zero range). Peak amplitude of the pretrigger will range between 10 and 75 volts. The sweep generator shall utilize the azimuth change pulses generated by the Azimuth Data Converter or Azimuth Pulse Generator (3.6.1.1.12) to resolve the sweep voltage into sine and cosine components for driving the PPI fixed deflection coil in a push pull mode, thus producing sweep rotation in synchronization with the ASR antenna azimuth position. No mechanically rotating device shall be employed in the sweep generating or deflection circuits.

<u>3.6.1.1.5.1 Sweep Linearity</u>.- Centered sweep linearity shall be measured with the sweep origin in the center of the CRT screen, and with the sweep rotating. Deflection shall be measured as though viewed from an infinite distance along the tube axis. It shall be possible to adjust the sweep length and linearity controls to permit exact placement of all range mark circles (for example, the 2-nautical mile circles for the 6-nautical mile range) on their exact theoretical deflection circles simultaneously, with the sweep origin at the center of the CRT screen. At the four cardinal lines 0°, 90°, 180°, and 270°, all range distances shall be represented by deflection to within $\pm$ 1 percent of the CRT screen usable radius (0.1 inch for a 20-inch CRT screen usable diameter) of the theoretical deflection, and to within $\pm$ 2 percent of the CRT screen usable radius of the theoretical deflection between the cardinal lines. Particular care in the sweep design shall be given to incorporate provisions to meet the sweep linearity requirements at very short ranges on all PPI sweep ranges. In the off-centered position, the 0-range distances from one radius to one diameter shall be represented by deflection to within $\pm$ 1 percent of the CRT screen usable diameter of the theoretical deflection throughout the sweep rotation visible on the PPI in the off-centered condition. The origin of the sweep shall not deviate from a point by more than 0.05 inch during the complete sweep rotation, with the sweep origin placed at any point on the scope face.

<u>3.6.1.1.5.2 Sweep Curvature</u>.- The sweep trace curvature shall not exceed 0.05 inch with the sweep origin centered, or 0.1 inch with decentering to any position specified in 3.6.1.1.4. For purposes of these requirements, curvature shall be considered the maximum deviation of the trace from a straight line between the sweep origin and the intersection of the sweep with a circle, whose radius is equal to the CRT screen usable radius. Measurement of the sweep curvature in off-centered position shall be made with the sweep off-centered 1 radius and passing through the center of the CRT.

<u>3.6.1.1.6 Focusing</u>.- The 22-inch CRT spot diameter shall not exceed 0.020 inch with 18 KV anode voltage, and beam current of 50 microamps. Ratio of maximum-to-minimum spot size along the sweep trace shall not exceed 1.5 to 1 for any angle of the sweep across the screen with the origin either centered or decentered to any position specified in paragraph 3.6.1.1.4. No noticeable change in focusing shall occur with changes of video input level to the CRT, such as between video and low intensity range mark circles.

<u>3.6.1.1.7 Intensity and Focus Variation</u>.- It shall not be necessary to change the sweep intensity or focus when PPI range scales are changed. Stability and regulation shall be such that the sweep intensity control shall not require

adjustment more frequently than daily. A maintenance intensity control shall be provided in back of the console front panel. A vernier intensity control, providing adjustment to compensate for variations in ambient illumination, shall be provided on the front panel of the console. The range of the vernier intensity control shall not be large enough to permit accidental burning of the CRT phosphor over the production range of tolerances of cathode ray tubes and other electronic parts. A front panel focus control shall be provided, whose range shall be sufficient to definitely de-focus in each direction from the optimum focusing adjustment and, at the same time, not be critical in adjustment. The console front panel focus and intensity controls shall be press-to-engage type of controls, which disengage under spring tension when released. Provisions shall be made to vary the CRT bias, or CRT video drive signal, or both with respect to sweep time such that, for constant amplitude input signals, the displayed video intensity is uniform with ± 10 percent over the face of the CRT. In addition, adjustable peak limiting or clipping of the CRT video drive signal shall be provided. The range of limiting shall be cut-off voltage.

3.6.1.1.8 Display System Accuracy and Resolution.- The requirements for accuracy and resolution specified herein, as well as all other performance requirements of this specification, shall be met under normal and service conditions as specified in Section 3.12 of this specification. Stability of the sweep generating, focus, deflection, and range mark generating circuitry shall be such as to remain in tolerance without readjustment over a 200 hour operating period under normal test conditions.

3.6.1.1.9 Distance Accuracy.- The distance accuracy of the system shall be such that the distances of targets relative to the sweep origin can be determined by reference to adjacent distance marks with an absolute error not to exceed 2 percent of their true distances, or the distance represented by 0.05 inch on the face of the indicator.

3.6.1.1.10 Resolution.- The PPI display equipment shall be capable of resolving two video input pulses of 0.8 ± 0.1 microsecond duration spaced 1.25 microsecond from leading edge to leading edge. The pulses shall be considered resolved when they are displayed as two readily discernible concentric rings as the sweep rotates at 15 RPM. This test shall be performed on the 10-nautical mile range with the input signals applied to any of the video input jacks at any range between 1 and 10-nautical miles. Video amplitude and sweep intensity controls shall be set for optimum operation.

3.6.1.1.11 Azimuth Tracking Accuracy.- The rotation of the PPI sweep shall follow the azimuth input data regardless of fluctuations of antenna angular velocity as may result from wind loading, to within 0.088 degree (the angular distance between azimuth change pulses). Provisions shall be incorporated to compensate for displacement of the ARP pulse up to ± 50 ACP pulses from the antenna north position. When the input data is correct, i.e., 4096 ACP pulses between each ARP pulse, no jitter or "jump" of the sweep in excess of the angular distance represented by the spacing between ACP pulses shall occur at any point during the sweep rotation, including the time of reset (ARP time). Adequate multiplying of ACP's shall be provided to prevent apparent bunching on "spoking" of the radar sweeps because of the relationship of the number of ACP's to the PRF. The display shall be capable of operating normally with ACP pulse to pulse jitter of as high as 50 percent of pulse spacing.

3.6.1.1.12 Digital Azimuth Data Characteristics.- The display shall be capable of operation with azimuth change pulse and azimuth reference pulse inputs provided over separate coaxial cable by the ASC. With the displays operating or turned off, all signal input impedances shall not be less than 5000 ohms. One BNC with a T connector shall be provided for each pulse input so that the input cable may be either terminated into a resistive load or extend to another display.

3.6.1.1.13 Input Video Characteristics.- The displays shall receive radar pretrigger normal and MTI video from the ASC. Beacon video shall be provided from the DDAS display video generator (DVG). Map and spare video will be provided locally and shall have the characteristics of condition 1. A BNC T-connector shall be provided for radar pretrigger and for each video input so that each input cable may be either terminated at its characteristic impedance or extended to another display.

Condition 1

Trigger Amplitude	10 to 75 volts
Trigger Position	20 to 120 microseconds ahead of radar zero range
Trigger PRF*	675 to 1200 pulses per second
Normal Video Amplitude	2.0 to 4.0 volts
MTI Video Amplitude	2.0 to 4.0 volts
Map Video Amplitude	2.0 to 4.0 volts
Beacon Video Amplitude	2.0 to 4.0 volts

* ASR-7 radars normally operate in a six stagger period mode, Figure 3.6-4 provides characteristics of this operation.

Condition 2

Uncompensated radar data inputs will have the following characteristics:

Trigger Amplitude	3.0 volts minimum
Trigger Position	Same as Condition 1
Trigger PRF	Same as Condition 1
Normal video amplitude	0.5 volts minimum
MTI video amplitude	0.5 volts minimum
DC Baseline Level	3.0 volts maximum

3.6.1.1.14 Acquisition Signal Conditioner (ASC Line Compensator/Amplifier
This unit shall receive radar video and trigger inputs as specified for Condition 2, (3.6.1.1.13.). The trigger outputs similar to those listed under Condition 1, (3.6.1.1.13.). The fidelity and recovery characteristics of the video and trigger compensating/amplifying equipment, when operating through 12,000 feet of RG-13A/U or equal coaxial cable, shall be such as to faithfully reproduce the video and trigger output of the radar transmitter-receiver equipment. The line compensator/amplifier shall compensate for line loss and phase shift versus frequency for video and triggers remoted over the coaxial lines. Compensation for line lengths from 0 to 12,000 feet shall be provided by solder-in straps. More than 3db of peaking at very low or high frequencies with respect to the mid-band frequency is not acceptable. The line compensator/amplifier shall attenuate, by a minimum of 20db, any AC power frequency potential appearing on the input coaxial line as a result of differences in ground potential between the transmitter and indicator sites. The line compensator/amplifier shall separate the normal video and the radar pretrigger. The line compensator/amplifier shall provide dual video outputs driving external equipments having the characteristics for videos defined by Condition 1 (3.6.1.1.13.) as well as video output for driving up to 11 RADS consoles. There shall be three pretrigger outputs for driving external equipments having the characteristics for triggers defined by Condition 1 (3.6.1.1.13.) as well as a pretrigger output for driving up to 11 RADS consoles.

3.6.1.1.15 Range Marks.- Range marks which intensity - modulate the sweep and describe continuous circles as the sweep rotates shall be provided for all ranges. The range mark interval shall be controlled by a three position range mark switch (2 mi, 5 mi, 10 mi). Any one of the three range mark intervals may be displayed on any selected range. The amplitude (intensity) of each fifth range mark shall be separately adjustable from the intermediate range mark amplitude by means of a maintenance control. The range of this maintenance control shall be such that the displayed intensity of the fifth range mark may be twice as great as the intensity of the intermediate marks. With the range mark level difference established, all the combined range marks shall be adjustable in intensity from zero to excessive brightness by a console front panel control.

3.6.1.1.16 Range Mark Generator.- The PPI console shall incorporate a range mark generator capable of producing the range marks specified in 3.6.1.1.15. All range marks shall be derived directly, or by counting down, from a common, frequency-stable oscillator so that all range marks are traceable to a single frequency source. The combination of accuracy and stability of the basic range mark timing oscillator shall be such as to produce 1 nautical mile range marks accurate to within ± 1/64 of a nautical mile over a week period of operation. The frequency of the basic range mark timing oscillator shall be adjustable over a range sufficient to compensate for tolerances of replacement components and for long term drift. The time intervals between range marks shall be equal and constant, within the limits specified above, and no spurious range marks shall be displayed. A maintenance control, separate from the sweep start control, shall be incorporated to permit adjustment of the zero range mark to be coincident with ASR zero range and to precede or follow ASR zero range by at least ten (10) microseconds with no noticeable jitter. The range of this control shall be adequate to accommodate synchronizing pretriggers timed from 20 to at least 150 microseconds ahead of the main radar pulse (zero range). Range of pretrigger amplitude will be between-10 and 75 volts. A maintenance control shall be provided to adjust the upper limit of the front panel range mark intensity control. Independent intensification of each fifth range mark, counted from the first mark after zero range, shall be provided in accordance with 3.6.1.1.15. Range mark duration shall be 0.1 ± 0.05 microseconds.

3.6.1.1.17 Video Mixing.- Each PPI console equipment shall have individual video mixing circuitry with five (5) inputs. Radar MTI and Normal video, Beacon Video, Map Video, shall be fed separately into the video mixer. With individual or composite 2-volt video inputs, the console video bandwidth, gains and levels shall be sufficient to drive the output of the video amplifier to maximum output level. This shall be sufficient voltage swing to meet the tube modulation level as specified by the tube manufacturer with no limiting or pulse distortion. Provisions shall be made for matching background levels so that the appearance of the noise background and signal intensity shall be essentially the same for MTI Video and Normal Video with equal inputs. Each PPI console shall be provided with controls permitting the selection of either radar video only or combined radar and map beacon videos through the adjustment of video brilliance. A separate map video gain control and a separate beacon video gain control shall also be provided on the front panel. A front panel video gain control shall be incorporated on the console front panel to control the gain of the combined MTI/Normal Video presentation. Separate maintenance MTI Video and Normal Video gain controls shall be provided in back of the console front panel to set up the individual MTI and Normal video levels. The combined MTI/Normal video gain control shall control the gain of a stage in the video mixer at which point the MTI and Normal Videos have already been mixed, in accordance with the levels set up by the maintenance MTI and Normal Video gain controls. In addition, a background video (Normal Video fade-in during MTI presentation time) gain control shall be provided on the front panel of the console. Brilliance of the radar, spare video, Map, and Beacon Video shall be independently variable. Each control shall be capable of adjusting the video gain over a range of at least 40db. To prevent the possibility of improper relative settings of console front panel video and IF gains controls, the video levels are maintenance set so that with console front panel video gain controls fully clockwise, a video presentation just slightly more intense than optimum results. Maintenance upper limit controls shall be incorporated in back of the console front panel for the Map, Background, Beacon, Spare, and gated MTI/Normal Video, front panel gain controls to permit the maintenance technician to set the upper limit of these controls. The limit controls shall limit or "clip" the peaks of the video only and not affect lower level video. Operation of either or all of the gain controls and maintenance video controls shall affect the display of only the console on which they are located. The front panel video gain control or MTI/Normal, Background, Beacon, Spare and Map shall cut off its respective video amplifier and, thereby, reduce the video output to zero when the control is at its counterclockwise limit. The method of video mixing shall be as follows: Map Video, Range Marks, and the Spare Video channel (designated as group 1) shall be non-additively mixed. Gated MTI/Normal Video and Beacon video (designed as group 2) shall be non-additively mixed separately from group 1. Groups 1 and 2 shall be additively mixed or form a single, composite video signal.

3.6.1.1.18 MTI/Norm... Video Range Gate.- Provisions shall be made at the console for controlling variable range gating of the MTI video from zero to a maximum range of 60 nautical miles, with MTI video appearing between zero and the selected range and Normal video appearing beyond. The MTI/Normal gating control shall be a console front panel control. With the MTI/Normal video range gate control fully counterclockwise, a maintenance lower limit adjustment behind the console front panel shall adjust the MTI range to zero; and with the MTI/Normal video range gate control fully clockwise, a maintenance upper limit adjustment behind the console front panel shall adjust -the MTI range over a minimum range of 10 nautical miles to 60 nautical miles. The transition from MTI to Normal video shall occur in less than 1/2 microseconds at the selected range. No loss of sensitivity due to the transition between MTI and Normal video shall occur at any range selected. Base line balance between MTI and Normal presentations 3.6.1.1.17. shall be of such stability as not to require adjust-ment more frequently than weekly. There shall be no humping-up of base line at the start of MTI presentation time or at the start of Normal presentation time, and the base line balance control shall not be utilized to minimize such effects. There shall be no guidance of position or negative transient existing at the start of MTI presentation or at the transition point between the MTI and Normal presentations. Gating at all ranges shall not be critical in adjustment. The stability of the gating shall not be critical in adjust-ment. The stability of the gating shall be such as not to require resetting more frequently than daily if it is desired to hold the gate at any one range, even at short ranges where the transition may not normally be set. Variation of the range gate control shall affect only the presentation of the console on which the control is located. Adequate clamping shall be provided in the video mixer stages to result in proper video mixing of various levels of all inputs and for all settings of all inputs and for all settings of the MTI/Normal Video range gate control. Variation in the settings of the MTI/Normal Video range gate shall not result in changing output video levels. A console front panel switch to turn the MTI/Normal range gate on/off shall be incorporated. With the MTI/Normal range gate off, a complete Normal video presentation shall exist. Provision shall be made at the console front panel for controlling the degree of mixing of Normal and MTI video to provide normal signals as background for MTI signals. Background normal signals shall be capable of being adjusted from zero to full Normal video level, and the accomplishment of these requirements shall not be a function of component selection in the gating and video mixing circuitry.

3.6.1.1.20 Video Amplifier.- The video amplifiers shall be responsive to both the radar video and the alphanumeric video.

3.6.1.2 Alphanumeric Requirements.- The display equipment shall decode digital data from the Data Processing Subsystem into function commands, CRT gross positioning and alphanumeric symbology. This data shall appear on the the CRT as positioned addressed aircraft formats and tabular information.

3.6.1.2.1 Format Generation.- Digital data shall be decoded as to address data, command data, alphanumeric symbols, and instruction codes. The address data shall be at least, 11 bits X and 11 bits Y. Format data shall be addressed either to a target position or to a tabular list. The target position address is adjusted for range scale and/or off-centering external to the format generator. Addresses for the tabular areas are transmitted to the display console in the format messages and are not adjusted for range scale and/or offcentering.

3.6.1.2.2 Aircraft Formats.- Aircraft formats will consist of a grouping of data related to a specific target on the display. This grouping may include a target symbol, A/N tag, and a leader from the target symbol to the A/N tag.

The target symbol shall be positioned on the CRT at the X, Y coordinates determined by the Data Processing Subsystem. The assigned target symbol shall be a variable under computer program control. Selection of the symbol shall be from the character generator repertoire.

3.6.1.2.2.2 Leader Generator.- A leader shall be drawn from the target symbol at the aircraft target position to the alphanumeric tag associated with the symbol. The direction of the leader shall be determined by the DPS. Leaders shall be oriented in one of eight evenly spaced directions (NE, SE, SW, NW, N , E, S, and W). The length of the leader shall nominally be five percent of the display diameter. The leader length shall be operator adjustable from zero to one tenth of the display diameter in approximately eight equal steps. When the formats are placed to the left of the target, the characters shall be right justified in order to associate the leader with the alphanumeric data.

The leader shall not differ from a straight line by more than .010 inches or 1 percent of the leader length, whichever is greater, and there shall be no visually discernible spikes, hooks, or jaggedness. The leader origin shall be adjustable (maintenance adjustment) from the center of the target symbol to a point at least 0.15 inches from the center of the target symbol. The leader shall in no case over write any target or data tag symbol. The leader shall terminate nominally one half a character width from the closest point on the first or last data tag character (as appropriate) for all character sizes. When the leader length is adjusted to zero, there shall be no overlap between the aircraft data target and the target symbol.

3.6.1.2.2.3 Full Data Block Fields.- The FDB composite aircraft tag (Figure 3.6-7) shall consist of a maximum of 7 data fields. The data fields are:

(a) First Line:

- Field 1 - Aircraft identification up to 7 alphanumeric characters.

(b) Second Line:

- Field 2 - Altitude and control symbols up to 4 characters.
- Field 3 - Ground speed or message data. Two characters.
- Field 4 - One character.

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(c) Third Line:

- Field 7 - Low altitude and conflict alert up to 5 characters.

(d) Targets:

- Field 5 - Target symbol of the console.

(e) Leaders:

- Field 6 - Line associating target symbols with alphanumeric tag.

3.6.1.2.2.4 Field Filtering.- The controller shall have the capability of inhibiting, on his own display, any one or more of the fields in all FDB aircraft formats including target symbol and leader. Under program control, any particular field or all fields can be "forced" to be displayed completely, thus bypassing manual field filtering switches. Fields 3, 4, and 7 may not, however, be deselected. The controller shall also have the capability of deselecting the position symbols of other consoles.

3.6.1.2.3 Tabular Areas.- It shall be possible to position tabular data to any area on the CRT face. Tabular data consists of preview data, system data, a list of aircraft identification, coast/suspend data, and alert data. This data shall be displayed separately at several addresses on the CRT. All tabular areas shall be capable of displaying 32 lines of 32 characters per line. Tabular data output to the displays shall be positioned independently of range and off-center control settings.

3.6.1.2.4 Alphanumeric Generator.- The alphanumeric generator shall use a stroke drawing or equivalent technique to convert the printable character codes in the display data message to the proper analog waveform for presentation as alphanumeric characters on the display. Assuming a stroke writing technique is used, the character generator shall be capable of utilizing at least 15 strokes for the most complex character. Also, the character generator shall operate asynchronously so that, upon completion of any function, (both internal and external), it shall immediately proceed to the next operation. Consideration should be given to the use of expanded characters to generate tag leaders.

3.6.1.2.5 Display-Repertoire.- The display generation equipment shall generate the digits 0 through 9, the 26 capital letters of the alphabet, and 9 special symbols: asterisk (*), virgule (/), delta (Δ), square (□), period (.), plus sign (+), error (ᴲ), up (↑), and down (↓). Provision shall be made to permit symbols to be added to the repertoire by field modifications up to a maximum of 54. The specific character front to be used by the contractor shall be submitted with the Design Data for Government approval.

3.6.1.2.6 Blink and Force Capability.- Under program control, the display generator shall be able to blink any or all data fields in any Full Data Block. Any or all FDB data fields may also be "forced", thus, overriding any normal display inhibit selection.

In the case of Limited Data Blocks, the display generator shall be able to force the entire data block including symbol and leader (overriding beacon filter switch settings) and blink both the position symbol only and the entire data block (including symbol and leader) under program control.

<u>3.6.1.2.7 Height</u>.- The character height shall be front panel selectable in four discrete steps: 0.10 inch, 0.12 inch, 0.13 inch, and 0.15 inch. Legibility tests shall be conducted at 0.12 inch at both the center and edge of the CRT. Character height shall be with ± 5 percent of the selected size at any point on the CRT. Character size shall also be maintenance adjustable so that the entire size range may be shift ± 25 percent.

<u>3.6.1.2.8 Aspect Ratio</u>.- The ratio of character height to character width shall be 3:2 nominal. The characters, *, +, △ , and □ shall be presented as wide as normal alphanumeric characters but shall have approximately a 1:1 aspect ratio.

<u>3.6.1.2.9 Spacing</u>.- Character spacing shall be automatically adjusted when character size is changed. Horizontal spacing between successive characters in a horizontal row shall be maintenance adjustable from 1/16 of the character height to 1/4 of the character height. Vertical spacing between successive characters in a vertical column shall be maintenance adjustable from 1/6 of the character height of 1/2 of the character height. The horizontal and vertical spacing and aspect ratio shall not exhibit space-to-space variation greater than 10 percent of the nominal values.

<u>3.6.1.2.10 Character and Leader Line Width (Trace Width)</u>.- The line width of characters and leaders shall not exceed 0.028 inch and the average line width of a set of five measurements made in the center, upper right, upper left, lower right, and lower left areas of the CRT shall not exceed 0.022 inch. These measurements shall be made with the CRT adjusted for best overall focus across the full CRT at a CRT intensity of 4 foot lamberts and with an incident light of approximately 0.2 to 0.3 foot-candle on the face of the CRT. Tests shall be conducted at the CRT edge and center for a character height of 0.13 inch on a 20-inch usable diameter display. Line width shall be measured by determining the distance between half brightness points of the line using a Celeco two-split analyzer or equivalent. Measurements shall be made at the line writing rate and at full brightness.

<u>3.6.1.2.11 Fidelity</u>.- Characters shall be displayed as sharp, focused, clear-cut block characters without accumulative directional errors, skew, bright spots, or gaps.

All characters shall be immediately and easily recognizable and discernible. Line segments of a character shall close within 50 percent of a line width. No noticeable change in focus shall occur with changes in brightness. Display presentation shall be such that no visual anomalies or spurious responses occur when an attempt is made to write data off the face of the screen. All of the above requirements apply to all character heights except 0.10 inch character height.

<u>3.6.1.2.12 Stability</u>.- Peak-to-Peak short term drift, jittering or jumping of characters and leaders shall not be discernible. Performance shall be such that display adjustments, except for brightness, shall not require adjustment

more frequently than weekly to meet the requirements of this specification. Brightness adjustment shall be required no more frequently than daily.

3.6.1.2.13 Baseline Straightness.- The straightness of any 15 character line or column of alphanumerics shall not deviate from a straight line by more then ± 10 percent of the nominal character height. The height variation for adjacent alphanumerics shall not exceed ± 5 percent of the character height.

3.6.1.2.14 Positioning Accuracy.- Characters on the displays shall be positioned at the point designated by the X, Y coordinates contained in the digital data message with an absolute accuracy of ± 1.0 percent of the display diameter. A relative error between data groups separated by less than 20 percent of display diameter shall be less than 0.1 percent of the display diameter.

3.6.1.2.15 Refresh Rate.- The display shall operate under program control at a maximum of 30 Hz for normal display loads and shall degrade gradually as the load increases.

3.6.1.2.16 Blinking of Data.- Data shall blink under program control. The consoles shall respond to commands to initiate blink and stop blink. The normal blink rate shall be four cycles per second with symmetrical on/off periods. The rate shall be maintenance adjustable over the range from 1/2 cycle per second to five cycles per second.

3.6.1.3 Display Model.- The displays shall have the capability of presenting in a single display all the formats shown in Figure 3.6-2. The refresh rate for this quantity of data shall not be less than 24 Hz. No format splitting shall be permitted between pulse periods except at end of symbols, end of leader, or end of a line, unless accomplished with no visible effects and while meeting all requirements of Section 3.6 of this specification.

3.6.1.3.1 Deflection System.- The X and Y deflection amplifiers are required to fully deflect the CRT beam and settle it to any point on the CRT at a rate that shall not cause a smear of the alphanumeric and/or radar video. A protection circuit shall be incorporated to inhibit the deflection current when the trace exceeds the visual area of the CRT face. Circle rounding shall be included. A second protective circuit shall be included to blank the CRT should the deflection circuit fail. The settling and hysteresis shall be such that perceptible motion of fixed-position alphanumeric data on the CRT shall not exceed 0.020 inch, as measured in either the vertical or horizontal axis of the CRT screen with a 20-power microscope under normal system operating conditions.

The deflection system for the displays (gross positioning and symbol/line generation) shall be a value-engineered system using a high speed, air core or equivalent, main and character writing deflection system.

3.6.1.3.2 Time Share Switch.- The time share switch shall be controlled from the radar PRF rate. The consoles shall display a maximum of 55 nautical miles of radar video. The video presentation shall be interrupted at 55-nautical mile return and computer random position writing shall continue for a PRF dependent 133 microseconds minimum. The time relationship is shown in Figure 3.6-3.

3.6.1.3.3 Dead Time Availability.- The radar PRF(s) (and, therefore, the associated beacon PRF) selected on the basis of non-interference with other facilities and other site considerations, is fixed. Available dead time periods must be loaded with alphanumeric formats, while maintaining the specified display model (Figure 3.6-2). As seen by the ARTS IIA equipment, triggers and video from ASR-3, -4, -5, and -8 and the associated beacon and the ASR-9 SCIP are unstaggered, i.e., triggers occur at regular intervals. The ASR-7, however, will normally provide staggered radar and beacon triggers, i.e., radar triggers will occur in a fixed repetitive sequence, each sequence consisting of six discrete time intervals; beacon triggers will occur in a similar sequence, except that there are eight discrete time intervals.

Both radar and beacon video are time synchronous with their respective triggers. The basic clock of the ASR-7 is frequency variable over a limited range, thus the PRF's can be varied somewhat. Figure 3.6-4 illustrates the nominal, shortest set of pulse periods; the clock frequency may be decreased by as much as 5 percent below its normal frequency, thus establishing the longest set of pulse periods.

3.6.1.4 Composite Display Functions.- This section specifies composite functions for the operational displays (also see Figure 3.6-5).

3.6.1.4.1 Brightness.- Brightness is defined as the light output of an element of data being displayed on the cathode ray tube measured in foot lamberts. For the purpose of this specification, brightness shall be considered the light output of an element of the written data, the element being the writing trace. The measurement shall be made under operating parameters which result in the specified resolution of selected printed data, such as an alphanumeric character or line data for which it is desired to determine the brightness. The display shall be capable of writing data up to a maximum specified brightness while maintaining the specified resolution. The brightness shall be measured using a Photo Research Corporation Model "Pritchard" spot brightness meter with a SPECTAR 1962-DD object lens, and two minute aperture or equivalent. The element of written data measured shall be a segment of a character or line as appropriate to the measurement being taken.

3.6.1.4.2 Brightness Level of Computer Generated Data.- The display shall be capable of presenting output data at 4 foot-lamberts with a minimum contrast ratio of 10:1 while meeting all spot size and line width requirements herein. The incident light shall be 0.2 to 0.3 foot candles and the refresh rate shall be 30 Hz.

3.6.1.4.3 Brightness Variation.- Variation of brightness measurement at 4 foot-lamberts shall not exceed 50 percent. This applies to inter and intra-character brightness, inter and intra-leader brightness as well as variations between leaders and characters (brightest leader spot compared to dimmest character spot and vice versa). Cross over points on characters or other points of character stroke intersection where the angle of intersection if 90 or less, will be excluded from this requirement. All the above requirements apply to all character heights except the 0.10 inch character height.

3.6.1.4.4 Registrat... Between Video and Computer-Gen...ated Data.- Video and digital data shall be clamped at the display coordinate center as the rho-theta scan start at the zero X and zero Y voltage point of the digital coordinates (i.e., digital address 10 bits plus sign or total of 11 bits allowing ± 10 bits from center reference). Video and digital data register within 1/8 nautical mile or 0.2 percent, whichever is the larger, at any point of the display including range scale and off-center positions.

3.6.1.4.5 Decentering.- The computer generated data shall be referenced to the radar origin and decentering shall be performed using analog or digital techniques by common circuitry for both the computer generated data and video data. It shall be possible to off-center the radar origin in any direction up to one radius.

3.6.1.4.6 Fail Soft.- The broadband and alphanumeric portions of the Data Entry and Display Subsystem shall be designed so that a failure in one portion shall not cause the other portion to become inoperative unless the failure occurs in circuitry common to both portions. If the inputs to either portion fail, the subsystem shall continue to operate.

3.6.1.5 Data Entry Requirements

3.6.1.5.1 Data Entry Devices.- The data entry devices to be incorporated with the display shall consist of the following elements:

(a) Alphanumeric and category function keyboard

(b) Positional Entry Module (PEM)

(c) Control Switches (quick look, beacon filter, etc.)

The A/N keyboard and PEM shall be designed to be as small as practicable, portable and movable. The PEM and enter key shall be attached to and easily removable from the A/N keyboard. Provisions shall be included for mounting the PEM at two different positions on either the right or left side of the A/N keyboard in Figure 3.6-6. This unit shall be interconnected with the console via a plug and flexible cable.

3.6.1.5.2 Alphanumeric and Category Function Keyboard.- The alphanumeric and category function keyboard shall be used to enter A/N data for transmission to the CPM. The keys shall be modular and configured as shown in Figure 3.6-6. Each key shall utilize a high reliability switch. Encoding shall be accomplished by means of an electronic technique. Provisions shall be made for up to sixteen functions. It shall not be possible for the controller to accidentally generate bad parity in messages to the DPS.

3.6.1.5.2.1 Keyboard Construction.- The alphanumeric keyboard shall be a maximum of 8 1/2 inches wide, 9 3/4 inches long, and 4 inches deep.

Quick look switches, field select switches, and beacon filter switches shall not be part of this keyboard module. All switches shall have their function engraved on the key caps. The dimensions, color schemes, and other particulars shall be furnished to the contractor 30 days after contract award. The contractor shall submit key and switch samples as well as precise keyboard dimensions in the System Design Data. The A/N key-board shall have convenient plug-in-connection and flexible cable whereby it may be easily moved in the general area of use.

3.6.1.5.2.2 Keyboard Lighting.- Backlighting of the keyboard shall be provided so that all printed matter appearing on the keyboard shall be illuminated. An operator control such as a "thumb wheel" shall be provided in the keyboard module to provide a continuous control of the backlight intensity from full brightness to full off.

3.6.1.5.3 Positional Entry Module (PEM).- This device shall be used to move the positional data symbol to the desired position on the display and to cause the transmission of messages with X, Y position coordinates to the computer.

The position marker shall move in a direction corresponding to the direction of movement of the PEM at a speed dependent upon pressure applied. Movement shall be smooth with no discernible lags, jumps, or dead spots.

An enter switch shall be provided adjacent to the device to enter PEM counter X, Y address to the processor. Upon acceptance of X, Y address, the symbol shall return to a pre-set home position. The PEM counters shall be at least 11 bits X and 11 bits Y.

3.6.1.5.3.1 PEM Construction.- The Positional Entry Module and its associated entry button shall be contained in one unit which can be mounted on either side of the keyboard module or separately on the console shelf. Precise dimensions of this unit shall be included in the System Design Data to be provided 90 days after contract award. The Enter switch shall not extend more than 1/2 inch beyond the top surface of the PEM enclosure.

3.6.1.5.4 Quick Look Function.- The quick look capability shall be provided by a series of three position toggle switches which shall be capable of being operated in both a continuous "on" or a spring return to "off" mode. For program interpretation, there shall be only a "on" and "off" mode. When a switch is selected "on" on either position, a code representing that control position shall be transmitted to the computer. This code will be used by the program to select an additional set of data to be displayed. When the switch is moved to the "off" position an indication of this shall be transmitted to the computer and the program shall then drop the display of the additional data set. The spring loaded position shall supply "display while set" condition. It shall be possible for the controller to simultaneously have one, or more than one, quick look switch activated.

3.6.1.5.5 Beacon Filter Switches.- The beacon filter switches are three position switches and operate in the same manner as the quick look switches. The altitude filter switch, when activated, provides for an override on the Mode C altitude filter limits entered from the keyboard. The "all code" filter switch, when activated, provides for beacon code read-outs (Mode 3/A) on all targets. The selected code filter, when activated, provides for beacon code read-outs on all selected unassociated targets.

3.6.1.5.6 Field Inhibit Switches.- The depression of one or more these switches will inhibit from display its associated FDB field. Fields 3, 4 and 7 may not be deselected. Field 3 may be deselected because beacon level tracking is provide. The inhibiting of Field 3 sha.. be overridden by either software or hardware. Software provides for the override of any of the field inhibit switches by means of the force function. The field inhibit function shall be performed in the display.

3.6.1.6 Digital Data Interface.- The display shall be interfaced with the DPS. The alphanumeric display shall be refreshed from the DDCP. The buffering within the console shall be sufficient to insure that the display model can be met on any range and/or off-centering of the ASR radar video on all displays while they are operating at the data model loads specified in Figure 3.6-2 (or Figure 3.7.5-1 when operating in video compression mode).

3.6.1.7 Operational Controls.- Operational controls shall be placed within easy reach of the operators. The contractor shall provide human engineering to arrive at optimum placement. A detailed design and layout shall be included in the System Design Data to be submitted for FAA approval. The contractor shall be responsible for familiarizing himself with work the FAA has accomplished to date. Primary controls on the display discrepancies shall be protected by knobs that require push-to-turn action.

3.6.1.7.1 Console Controls.- The following controls shall be provided and located to be accessible to the operator.

(a) Radar Range: Two controls shall be provided for fixed and variable range selections. The fixed range control shall be a six-position switch labeled 6, 10, 20, 30, 60, and variable. The variable control shall be either continuous or incremental in steps of not more than 2 nautical miles between 6 and 60 nautical miles. The front panel nomenclature shall indicate range between 6 and 60 nautical miles. The placement of alphanumeric data shall follow radar placement as defined in 3.6.1.4.4.

(b) Range Marks: A three (3) position switch shall select 2, 5, and 10-nautical mile range marks. Every fifth ring shall be intensified on each range.

(c) Range Mark Intensity: This control shall vary the intensity of the range marks from zero (blacker than black) to full CRT intensity.

(d) Sweep Decenter Switch: This switch shall provide for normal centered and decentered display.

(e) Decentering Control: Decentering controls (N-S, E-W) shall be continuous or incremental steps of not more than 1/2 nautical mile (7 bits X, 7 bits Y) up to one radius decentering. The front panel nomenclature shall indicate amount of off-centering between zero and one radius.

(f) Center Controls: Vernier controls (N-S, E-W) shall provide minor correction to center the radar origin at the geometric center of the CRT.

(g) Background Video Gain: This control is restricted to addition of normal video to the MTI portion of the display. This permits the

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operator to \ w known ground targets when ch ing alignment with video map display. The normal video, beyond the video gate cross-over from MTI to normal is not affected by the control.

(h) MTI/Gate Switch: This switch is restricted to addition of normal video to the MTI portion of the display. This permits the operator to view known ground targets when checking alignment with video map display. The normal video, beyond the video gate cross-over from MTI to normal is not affected by the control.

(i) MTI/Normal Gate Adjust: This switch selects the type of video displayed. In the OFF position, normal video is displayed over the entire range. In the GATE position, MTI video is displayed from zero to a range determined by the setting of the MTI/Normal Gate Adjust control and normal video is displayed in the remainder.

(j) MTI/Normal Video Gain: This control determines the intensity of both normal and MTI signals on the display.

(k) Beacon Video Gain: This controls the level of beacon video entering the wideband video mixer.

(l) Map Video Gain: This control varies the intensity of the video map markings on the display.

(m) Sweep Intensity: The wideband data shall respond to this control from CRT cut-off to full unblanking. The operation of this control shall have no noticeable effect on the computer generated data presentation.

(n) Computer-Generated Data Brightness: This control shall determine the brightness of the computer-generated data presentation. The operation of this control shall have no noticeable effect on the wideband video presentation. Computer-controlled brightness shall track over 80 percent of the brightness range.

(o) Character Size: This 4-position switch shall provide selection of alphanumeric character size and spacing as specified in 3.6.1.2.7. and 3.6.1.2.9.

(p) Focus Control: This control shall vary the focus of CRT beam on the phosphor surface.

(q) Field Inhibit Switches: Eight inhibit switches shall be mounted on the display console panel shelf. Each switch shall have an on/off control with respect to the presentation of one of the fields of data subject to the limitation of 3.6.1.5.6.

(r) Beacon Filter Switches: Three switches which are used to override the Mode C altitude selections and to provide beacon code read-outs on targets. These are three-position switches, "on" and "off" and spring return to off.

(s) Quick Look Switches: Five three-position switches which operate as required by section 3.6.1.5.4. Means shall be provided so that the designations on these switches may be readily changeable.

(t) Leader Length Control: An eight position discrete switch.

(u) Master Power Switch: This switch shall control all power on the display console. It shall be properly mechanically-protected to prevent inadvertent operations.

(v) Compass Rose: The fixed compass rose placed over the CRT shall have illuminated graticule every 5 degrees with each 10 degrees identified by the actual number of degrees relative to North (0 degrees). This compass rose control shall vary the illumination of the compass rose.

(w) Console Panel Illumination: This control shall vary the illumination of all panel nomenclature.

(x) Maintenance Controls: All set up controls shall be placed in locations that facilitate adjustment i.e., controls adjusting basic parameters of the CRT shall be located whereby the maintenance technician can view the display CRT during adjustment. A control shall be included for the spare input to the Wideband Video Mixer.

3.6.1.7.2 Console Indicators and Illumination.- Each console shall have illumination and nomenclature for controls and indicators. As a minimum, the following shall be included:

(a) Indicator Lamps

(1) Power On

(2) Console Overheat

(b) Illumination

(1) Console Panel

(2) PEM and Keyboard

(3) Compass Rose

The nomenclature on the panel, where practical shall appear white in a brightly illuminated room or when the panel illumination is turned down. In a darken room, the lettering shall appear red and shall be derated to the extent required to meet the reliability requirements of the specification. All lamps shall be replaceable from the front of the equipment.

3.6.1.8 General Display Requirements

3.6.1.8.1 Power Supplies.- All power supplies furnished with this system, unless specifically exempted herein, shall be in accordance FAA-G-2100e and with the requirements of the subparagraphs herein. All regulated power supplies shall be self-protecting such that, without the use of fuses, circuit-breakers or other protective devices, a continuous short across the power supply output will not damage circuit components and the output voltage will return to norma pon removal of the short circu Fuses are permitted to be used for protection of non-regulated AC supply outputs used for lighting indicators and lamps.

3.6.1.8.2 Regulation.- All power supplies, except those specifically exempted, shall be electronically regulated to maintain output voltage to within ± 1 percent of the nominal value as the load is varied from 10 percent less than to 20 percent more than the normal load, and as the line voltage is varied between the service condition limits. Primary power line voltage regulators may be employed if required to meet this latter requirement. The output voltage of regulated supplies shall be continuously variable over a minimum range to achieve its nominal value and the regulation and ripple specifications shall be met for any value of the output voltage within its adjustment range. Power supply output voltage shall not vary by more than ± 1 percent from the initial setting during operation over the service conditions. The use of selenium rectifiers is prohibited. Each regulated power supply shall employ its own separate voltage reference device, and shall not rely upon another power supply for a voltage reference. Whenever practicable, individual chassis or modules shall be employed for each power supply. If a low voltage control circuit power supply is employed, it is not required to be electronically regulated.

3.6.1.8.3 Ripple Voltage.- Ripple voltages, defined as the peak-to-peak value of a simple or complex waveform consisting of power line frequency components and harmonics thereof, and synchronous or repetitive non-synchronous transients, shall not exceed 0.1 volts peak-to-peak for all electronically-regulated power supplies. The control circuit low voltage supply (if used) and CRT anode supplies are exempt from this requirement. The ripple voltage of all power supplies shall be such that all specification requirements are fulfilled and further reduction of the ripple voltage would not result in any significant improvement in the stability of operation circuit control adjustments or indicator presentation.

3.6.1.8.4 Bias Protection Circuitry.- Provisions shall be made to automatically remove the voltage from circuits which would be damaged by the loss of operating bias.

3.6.1.8.5 Metering.- Meters and associated switches for use in measuring all power supply output voltages and currents shall be provided, except where the contractor and the Government mutually agree that voltage test points would be sufficient or that no metering is required (where indications are not significant and where circuitry is unduly complicated). Meters shall preferably be located on the front panels of the cabinet containing the circuits to be metered but may be located elsewhere provided they are visible with the cabinet doors opened. When a meter is utilized to measure only the one parameter, the meter shall read directly. Each meter shall be provided with a replaceable card insert mounted near the meter to designate the proper reading of each associated switch position. If a meter cannot be used for multiple functions without external shunts or multipliers, such shunts for multipliers shall conform to the requirements of paragraph 3.5.5.12. of Specification FAA-G-2100e. Operation of meter selector switches shall not interfere with proper system performance such as might be caused by meter insertion to read current or transients caused by meter selector switching.

3.6.1.8.6 Line Voltage Regulators.- If the contractor elects to use line voltage regulators as a means of meeting system performance requirements under service conditions, at least one complete line voltage regulator shall be furnished for each PPI indicator and equipment cabinet provided. Constant voltage transformers (involving a combination of a resonant circuit and a high leakage reactance magnetic circuit) of the harmonic neutralized type (harmonic distortion of output voltage wave form of less than 3 percent) may be employed. All performance requirements shall be met with the voltage regulators in use and subjected to the service conditions along with the other equipment. If designed for use with line voltage regulators, the equipment shall be usable and component ratings shall not be exceeded if the equipment is operated continuously without line voltage regulators in place, over the range of line voltage and frequency specified under the service conditions; however, it is not required to meet specific performance limits without the regulators. Line voltage regulators shall be capable of being installed up to a maximum of 300 feet from the associated equipment; the contractor must consider this requirement when recommending the type and size of wire to connect the regulators to the loads. Suitable racks or brackets, each capable of mounting at least two regulators, one above the other, shall be furnished in the quantity required. The racks shall be self-supporting, but shall include provisions for bolting to the wall and the floor.

3.6.1.8.7 Primary Power.- All performance requirements for the system shall be met without readjustment when primary power supply voltages and frequencies vary, rapidly or slowly, between the limits as specified in this document. There shall be no discernible variation in system performance, including display presentation, during primary power line voltage changes. Line voltage and frequency variations shall be measured at the power source.

3.6.1.8.8 Primary Power Control.- Each PPI display console and each equipment cabinet shall incorporate a primary power switch to control the primary power input to the unit. If line voltage regulators are used, the input to the regulator need not be controlled by this primary power switch; however, a warning notice to this affect shall be prominently displayed in the equipment to avoid personnel hazards. Similar notices shall be included in appropriate sections of the instruction manual. The equipment primary power switch shall be protected, or guarded, as necessary to prevent accidental de-energizing of the equipment.

3.6.1.8.9 Display Consoles.- The console shall incorporate an easily removable (for example, by removing machine screws) writing shelf approximately 13 inches deep which shall be free and clear of equipment or attachments. If necessary, to allow extension of the CRT chassis or to provide access to alignment controls, the writing shelf shall be designed to slide. The writing shelf shall be cut out, or recessed if necessary to provide an unobstructed view of the entire usable face of the CRT from a normal seated position. The writing shelf shall have an easily removable, recessed, clear-plastic overlay. The design of the recess and of the clear-plastic overlay shall be such that no hinges are required while allowing the overlay to be easily raised or lowered. The top surface of the console shall be flat and free from such attachments as external blowers and shall not provide access to the interior. The sides and top of the console shall have no access doors nor any air intakes or exhausts. Internal units shall be easily removable from the front of the console for replacement and repair. Each unit shall have a hinged front access panel door except where it is impracticable, such as the units containing CRT indicators. Light shields or flanges shall be installed around the two console front panels surrounding the CRT to eliminate light leakage from the console interior. All adjustments and test measurements shall be made from the front either on the front panel adjacent to the front access panel door or immediately behind the front access panel door, except in the case of the unit containing the CRT indicator where such adjustments and measurements may be made accessible by partially withdrawing the unit from the console. The console construction shall be of such ruggedness that the maintenance adjustments performed with the CRT unit partially withdrawn from the console shall remain constant when the CRT unit is returned to its normal operating position. Console cables to each unit shall be of sufficient length so the unit can be operating when removed to the stop, or locked position without the use of extension cables. All cables (except coaxial) shall be connected to type 26 blue ribbon barrier polarized connectors with keyed latch shells. Terminals for coaxial cables shall be separate from other terminals and connectors shall be type BNC, or equal.

Extension cables shall be provided (except when the Government agrees that the design obviates the need to remove any assembly for maintenance) to permit convenient operation of all units simultaneously outside of the console on a maintenance test cart with or without test junction box in the circuits. If the contractor's design of the display console is such as that it provide for convenient operation/maintenance of all units without the use of extension cables, simultaneous operation of all units outside of the console on a maintenance test cart with or without a test junction box in the circuits shall not be required. However, if the Government determines from the actual display console configuration that certain units will require extension cables from simultaneous operation outside the console, or a maintenance deficiency exists, the contractor must provide required extension cables or correct maintenance deficiencies at no additional cost to the Government.

The contractor shall still be responsible for achieving the required system, subsystem, and display MTTR, and for satisfying all site maintenance requirements incorporated into the contract. Because of space limitations in locating the console in the TRACON operating room, easy access shall be provided for the servicing of all units and circuits from the front of the console. No electrical component or mechanical protrusions (such as connectors, blow fuse indicators, switches, etc.) shall extend beyond the console front surface below the writing shelf to act as footrests or to interfere with the legs of the controllers. The flow of ventilating air shall be from the lower rear to the upper rear of the console. Access to the rear of the console shall be required only for making external connections.

3.6.1.8.10 Console Audible Noise.- Noise of any console blower motors shall be minimized; in no event shall the combined noise from three consoles exceed the noise limits specified in FAA-G-2100e paragraphs 3.3.1.3.1 and 3.3.1.3.2.

3.6.1.8.11 PPI Console External Connections.- All external connections to the PPI console, including primary power, signals grounds, etc., shall be made through quick disconnect connectors or jacks on a panel centrally located on the rear exterior of the console cabinet. The panel shall be recessed so that no jack, connector, or plug extends beyond the surface of the console;

however, the panel itself, as well as all connectors, jacks, and plugs shall be readily accessible. The display shall be capable of meeting all specification requirements with input signal cable lengths of up to 500 feet.

3.6.1.8.12 PPI Console Mobility.- The PPI console shall be mounted on wheels, casters, or rollers so that it may be readily moved into or out of the operating position. The wheels, casters, or rollers shall not extend beyond the front or back of the console, nor more than 2 inches beyond the sides, nor shall the overall height of the console be increased by more than 2 inches by the addition of casters. The front wheels or casters shall be the swivel type to permit turning the console. Provision shall be made to lock rotation of at least the back wheels, and if the axles of the front wheels are not directly below the center point of swivel or pivot, provision shall be made to lock the swivel. Maximum dimensions of the display shall be as follows: width 30 inches, height 48 inches, and depth 54 inches.

3.6.2 TRACAB Configuration Description.- The system shall be capable of operating with GFE DBRITE tower cab displays. Figure 3.2-2 indicates the TRACAB configuration.

3.7 System Configuration, Modularity, Expandability

3.7.1 General.- The ARTS IIA system shall be designed so as to be modular and readily expandable. The basic system shall be capable of being expanded by adding computing, memory and input/output modules. It shall be possible to expand the system from one level to a higher level with a maximum of 30 minutes of system downtime.

3.7.2 Dual DPS/Dual Sensor Configuration.- The system shall be capable of expanding to a dual DPS configuration, with both single and dual sensors and with up to 22 displays and 44 keyboards. In the event of a DPS failure, the ARTS IIA shall be capable of operating in a limited configuration with one DPS while the other DPS undergoes repair. Three dual configurations shall be provided.

3.7.2.1 Dual DPS/Overlapped Dual Sensor.- This configuration shall combine two ARTS IIA systems into a single integrated system capable of operating 22 displays with 2 beacon systems. The beacon systems are located less than 55 nautical miles apart such that their coverage areas overlap.

3.7.2.2 Dual DPS/Non-overlapped Dual Sensor.- This configuration shall combine two ARTS IIA systems into a single integrated system capable of operating 22 displays with 2 beacon systems. The beacon systems are located more than 55 nautical miles apart so that their coverage areas do not overlap.

3.7.2.3 Dual DPS/Single Sensor.- This configuration shall combine two ARTS IIA systems into a single integrated system capable of operating up to 22 displays with a single beacon system.

3.7.2.4 Dual DPS Hardware Interface.- When two ARTS IIA systems are integrated into a single system it shall be possible to transfer data between subsystems over a high speed, bi-directional error checking, dual DPS interface. The dual DPS interface shall be capable of exchanging data between DPS's at a rate sufficient to perform the functions specified in paragraph

3.7.2.5.

3.7.2.5 Dual DPS/Dual Sensor Software.- The ARTS IIA software operating in the Dual DPS/Dual Sensor configuration shall provide all ARTS IIA functions described in paragraph 3.3 herein and shall provide for the complete integration of software functions between subsystems. The intersensor functions shall provide for an intersensor link, cross system hand-offs, dual sensor Conflict Alert, and a single point Interfacility and system monitor.

3.7.2.5.1 Intersensor Link.- The Dual DPS/Dual Sensor ARTS IIA software shall provide an intersensor link function that shall correlate associated tracks in one subsystem with beacon targets in the other subsystem so that associated tracks in one subsystem shall be displayed as such in the other subsystem. The intersensor link correlation shall consider position, altitude, heading and beacon code. The correlation shall be maintained through missing data situations.

3.7.2.5.2 Cross System Hand-off.- The ARTS IIA software shall allow normal hand off processing between subsystems.

3.7.2.5.3 Dual Sensor Conflict Alert The Dual DPS/Dual Sensor software shall allow Conflict Alert to function between tracks in overlapped subsystems. Each track shall be converted to a common geographical reference before Conflict Alert. Conflict Alert shall accommodate intersensor position errors.

3.7.2.5.4 Dual DPS/Dual Sensor Interfacility.- The Dual DPS/Dual Sensor ARTS IIA softw Flight Plan data shall be distributed to the appropriate display independent of which subsystem is attached to the display.

3.7.2.5.5 Dual DPS/Dual Sensor System Monitor.- The Dual DPS/Dual Sensor System Monitor may allow one of the two attached System Monitor Consoles to perform all system monitor functions for the whole systems.

3.7.2.6 Dual DPS/Dual Sensor Capacity.- The capacity of the Dual DPS/Dual Sensor system shall be as required in 3.10. for each subsystem. For Dual DPS/Dual Sensor system with overlapped coverage the total number of real tracks plus pseudo tracks shall be 102 per subsystem.

3.7.3 Additional Display Capability.- The system shall be expandable to up twenty two displays in any mix of TRACAB and TRACON displays. In such a fully expanded configuration, all displays shall be capable of simultaneously operating at the maximum range (55 nautical miles) with the system meeting all input and capacity requirements of 3.10 and 3.11 herein. Expansion to this maximum capability shall use the dual DPS configuration of 3.7.2. All functional requirements of this specification shall apply.

3.7.4 Peripheral Processor.- The ARTS IIA system shall be expandable to increase capacity by the installation of a peripheral processor in the system cabinet. (For a Dual DPS/Dual Sensor configuration there shall be one Peripheral Processor per subsystem.) The peripheral processor shall be interfaced to the CPM through an independent system network bus. The peripheral processor shall have sufficient processing capacity and memory to allow processing beacon tracking, Conflict Alert, Mode-C Intruder and Minimum Safe Altitude Warning for the load specified in 3.7.4.1. plus a 50% processor and memory reserve and assuming all software in implemented in a high order language.

3.7.4.1 Enhanced ARTS IIA Capacity.- The capacity of ARTS IIA when a peripheral processor is installed shall be as described in the following table.

Total Target Capacity (All Mode-C)	256
Full Data Blocks	102
Associated Tracks	102
Nonassociated Tracks	154
including:	
Limited Data Blocks	61
Single Symbols	93
Arrival/Departure Tabular List	93
System Data List (Lines Per Display)	12
Coast/Suspend List (Lines Per Display)	12
MSAW/CA Alert List (Lines Per Display)	5

3.7.5 Display Video Compression.- The ARTS IIA Data Entry and Display Subsystem shall be expandable to display the enhanced data model described in Figure 3.7.5-1. The enhanced capacity shall be obtained using a video compression technique designed to increase the available radar dead time by digitizing the live radar data on one sweep and displaying it on the next sweep at a faster rate. Video compression shall digitize the combined input video for each sweep into a minimum of 16 levels sampled at least once every 1/64 nautical mile and store it for display on the next sweep. The stored digitized video data shall be displayed at an accelerated rate providing a worst case radar dead time of 430 microseconds for a 1200 PRF radar. The refresh rate shall be a minimum of 24 Hz. and a maximum of 30 Hz.

The Video Compression modification shall be installed in the DEDS cabinet in available spare card slots and shall be able to be field installed in the DEDS in less than 8 hours. Other ARTS IIA components shall not require change solely to support video compression.

3.8 Reliability.- This section specifies the reliability requirements for the ARTS IIA system.

3.8.1 Subsystem Reliability.- The contractor shall submit in his design data predicted MTBF/MTTR reliability calculations for the subsystems using the methods contained in MIL-HDBK-217D and MIL-STD-756A. Each subsystem shall exhibit, as a minimum, the following reliability characteristics.

(a) The Decoding Data Acquisition Subsystem (DDAS)

(1) The DDAS function (non-redundant) shall have a MTBF of at least 3,000 hours. The DDAS function is defined as the DDAS capability required to operate the basic system in compliance with the specification in a normal underogated manner. As such, it depends upon all components in the DDAS and those components possibly external to the DDAS (such as power supplies, etc.) which could cause the DDAS to malfunction.
Since normal system operation need not make use of the analog decoding capability, this capability is specifically excluded from the DDAS function.

Redundant Azimuth Data Converters shall be used within the DDAS to meet the DDAS function reliability requirement. However, in the event of an ADC failure it shall be possible to restore the system to normal operation within 30 seconds.

The MTTR of the DDAS function shall be equal to or less than 0.5 hour.

(2) The Azimuth Data Converter (non-redundant) shall have a minimum of 15,000 hours and an expected life of at least 5 years. The MTTR shall be a maximum of 0.25 hours, assuming availability of spares.

(3) Redundant DDAS elements shall meet the same reliability standards as the basic elements.

(b) The Data Processing Subsystem (DPS)

(1) The DPS function MTBF shall be a minimum of 3,000 hours. The definition of the DPS function MTBF is analogous to that of the DDAS function. The DPS function includes the functions of the central processor, memory, memory manage-ment, interfaces, control units, adapters, and peripheral equipment.
The contractor shall submit reliability calculations based on the reliability model of the DPS in Figure 3.8-1. If the proposed subsystem differs from the model, an additional set of reliability calculations on the proposed subsystem shall be submitted. The MTTR of the DPS function shall be equal to or less than 0.5 hour.

(c) The Data Entry and Display Subsystem (DEDS) - The Data Entry and Display Subsystem operational console shall have the reliability characteristics as follows:

(1) The data entry module, which includes the PEM and elements in the table below, shall exhibit a MTBF equal to or greater than 10,000 hours, a MTTR equal to or less than 0.5 hour, and a replacement time of 1 minute. The reliability characteristics of the data entry module assumes the following frequency of continuous operations.

ELEMENT	ELEMENT MOST FREQUENTLY USED	ELEMENT LEAST FREQUENTLY USED
Function Select	6/hour	4/year
Field Select Switch	1/hour	1/year
Keyboard	30/hour	5/year
Quick Look or Beacon Filter Switch	6/hour	4/year
Other Controls	1/day	1/year
Indicator Lights	30/hour	1/year

(2) The display consoles and associated contractor supplied data entry and display control equipment shall have an MTBF greater than 3000 and an MTTR equal to or less than 0.5 hours with a replacement time of 4 minutes. The MTBF shall exclude display tubes.

The MUT/MTTR of existing "non-modified" components and subassemblies shall not be degraded. The MTBF shall exclude display tubes and vidicons.

3.8.2 Display Tubes.- Display tubes shall have a useful life of no less than 10,000 hours. This period shall include the guaranty period.

3.8.3 DDAS Analog Decoder.- The DDAS analog decoder function includes all the capabilities necessary to supply decoded analog data to the displays per Section 3.4. This analog decoder function is specifically excluded from the DDAS function as previously defined.

The DDAS analog decoder function MTBF (which is also dependent upon power supplies and other DDAS components) shall be a minimum of 7,500 hours. The MTTR of the analog decoder function shall be equal to or less than 0.5 hours.

3.8.4 System Reliability.- The system function shall include all the system capabilities required to normally operate the system in compliance with the specification in an underogated manner except for the number of displays; not that this specifically excludes the decoded analog function. In a TRACAB configuration, the system function shall be limited to having all system capabilities available at any two of the three DBRITE displays and input devices. In a TRACON configuration, the system function shall be limited to having all systems capabilities available at any four out of five IFR room and DBRITE displays in a system containing four IFR room displays and one DBRITE. A single display or entry device failure will thus not enter into the system function requirement.

The system function MUT shall be a minimum of 3,000 hours. The system function MDT shall be less than or equal to 0.6 hours.

The contractor shall submit in this design data predicted MUT/MDT data using the given model and applying the methods contained in MIL-HDBK-217D and MIL-STD-756A.

3.8.5 Component Reliability

3.8.5.1 Control Switches, Reliability.- All control switches shall be heavy duty, continuous-duty types. The number of different types of switches used in the equipment shall be kept to a minimum consistent with good design practices. All switches shall be rated equal to or greater than the peak current and voltage to be switched. Derating switches to increase reliability is recommended. Snap action switches shall be of the double break, self-wiping type, or of equivalent reliability. All switches shall be enclosed or provided with dust covers. Switches in inductive circuits or otherwise subject to surge currents shall be sufficiently derated or provided with arc suppression devices.

3.8.5.2 Indicator Lights and Lamps.- Lamps used in confined or totally enclosed spaces and/or in sockets subject to vibration shall be rated to meet the reliability requirements (3.8.1.). Panel lamps shall be replaceable from the front without requiring use of special tools.

3.8.6 Expanded System Reliability.- The reliability and maintainability of additional computing or memory units or interfaces which may be added to increase the system capabilities shall not deteriorate reliability figures any greater than the increased system capability thus obtained. In the case of additional logic elements (interfaces, computing units, etc.), the capability added shall be considered proportional to the additional number of active elements. Maintainability requirements shall not be allowed to worsen due to increased capabilities.

3.8.7 Reliability Design Features

3.8.7.1 Hardware Failure Sensing and Status Registers.- Parity generation and checking shall be provided on all data transfers within the system including transfers to and from all external interfaces and peripheral equipment. Parity checking need not, however, be performed in the display units on output data received from the DPS or on input data from the DDAS. Transfer to and from memory shall require the use of error correcting methods as described in paragraph 3.5.1.3. Parity shall be checked on all data input from display data entry devices.

Failure sensing and status registers shall be supplied within the system to meet the reliability, maintainability, and other requirements of the specification.

3.8.8 Recovery From Failure.- If a system module suffers any non-transient functional degradation due to internal failure(s), the module shall be declared to have failed. The repair of failed modules shall be conducted off-line and without interference to the display of radar/beacon video.

3.8.9 Recovery After a Power Failure.- Upon power failure or out-of-tolerance transient of line voltage, the system shall protect itself from damage and shall prevent loss or alteration of system data. When normal power levels have returned, previously stored data shall be displayed and all functions shall be available to the controller within 30 seconds after resumption of power. The requirements of this paragraph apply provided the system has not been inoperative longer than the memory retention period specified in 3.5.1.3.3. Power failure shall not result in the loss of any data stored in memory or hardware registers prior to the power failure.

3.8.9.1 Acceptable AC Power Transient.- The following AC power transient conditions shall not be considered a power failure and the system shall continue in normal operation.

(a) Transients that cause the line voltage to decrease to less than 90 percent of normal when

1. The transient is 8 milliseconds or less in duration and the line voltage is normal immediately prior to the transient, or

2. The transient is 4 milliseconds or less in duration and the line voltage is 90 to 95 percent of normal immediately prior to the transient.

(b) Transients that cause the line voltage to increase to more than 110 percent of normal but less than 130 percent when the transient is 17 milliseconds or less in duration.

(c) Transients that cause the line voltage to vary by ± 10 percent from normal for any duration of time.

NOTE (All reference to line voltage is line to neutral.)

An interruption (AC voltage has gone outside the range of 90 to 110 percent or nominal) may start at any time during a 60-cycle period with the requirements still applicable.

"Continue in normal operation" as used above shall be construed to mean that system operation remains normal in all respects except, if the duration of the AC power transient does not exceed 4, 8, or 17 milliseconds as specified in the conditions above, the only allowed abnormal effect on the system will be a momentary blink in the data presentation on the display console. This momentary blink shall have no more of an effect than if one frame of refresh was lost.

3.8.10 Independence of Subsystems.- Design of the system shall be that a component failure in any one subsystem shall not induce a failure in any other subsystem.

Failures in a redundant element or subsystem shall not affect the system operation unless specifically allowed elsewhere in this specification. It shall be possible to service and turn power on and off on the off-line redundant elements and subsystems without affecting the operation of the on-line elements. If dual CPM's are used in an expanded configuration, failure of one CPM shall not affect the second CPM or active elements connected solely to the second CPM except to the extent that a program load and restart may be required to resume ATC processing in the second CPM. In such a case, it shall be possible to resume operation utilizing the second CPM and the displays configured to it within 2 minutes of the initial failure. Failures in I/O channels and elements connected thereto shall not affect overall system operation or the proper operation of elements connected to other I/O channels.

3.8.11 Reliability of Peripheral Equipment.- All electro/mechanical peripheral equipment to be incorporated into the ARTS IIA system shall be designed for high reliability. High quality commercial components shall be used in their design and the individual units shall have a field history of reliable operation.

Magnetic tape units to be used in the system shall have a minimum MTBF of 4,000 hours under normal system operation. The error rates on data transfers from the magnetic tape subsystem shall be no greater than one soft error per 10^7 bits and no more than one hard error per 10^8 bits after 3,000 complete passes over the tape. A soft error is one which is recoverable within 1 second by automatic internal error recovery techniques. A hard error is any error other than a soft error. All mechanical components used in the tape units shall be designed to minimize preventive maintenance and shall have a service life of at least 20,000 hours of normal system operation.

Fixed media disc drives shall have a minimum MTBF of 25,000 hours under normal system operation. Removable (ie. floppy) media disc drives shall have a minimum MTBF of 15,000 hours under normal operating conditions.

3.9 Maintainability

3.9.1 General.- The software and hardware maintenance features as stated herein shall provide the means to meet the MDT and MTTR requirements as set forth in this specification. The contractor, using MIL-STD-470 as a reference, shall provide a maintenance philosophy that includes the following:

(a) The cost tradeoffs and reliability considerations involved in the application of both preventive and corrective maintenance.

(b) The number and skill level of maintenance personnel required to maintain the system.

(c) The level of the diagnostic support.

(d) The type of printed circuit board repair technique.

3.9.2 Maintenance Approach.- The preferred maintenance approach shall be to localize the failure through use of software and hardware maintenance features and to replace the failed module elements or plugable unit from those spare parts which the contractor shall furnish as on-site spares under the terms of the contract schedule. The actual repair of the replaced item should be accomplished at the convenience of maintenance personnel in a maintenance area or by the FAA Depot.

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Diagnostic software and maintenance features shall be designed to satisfy the module level. Where printed circuit boards are used, the replaceable module shall be considered to be the printed circuit board level, unless large boards with plug in integrated circuits are used. In this event, the replaceable module level shall be considered to be a number of IC's on a board.

3.9.3 Software and Hardware Features.- The maintenance software shall consist of data processor, diagnostic programs, and those programs developed for system integration that are capable of being used as system diagnostics. Hardware shall, to the greatest extent possible, present a software interface that allows application of computer program diagnostic techniques. These diagnostic programs shall be capable of being run on the system as normally configured for operational use without degradation of program detection/isolation capability. Hardware features shall include failure sensing and status registers, maintenance indicators, over-heating warning devices and cutoffs, test points, and maintenance adjustments.

3.9.3.1 Test Points.- Test points shall be provided for measurement and observation of such voltages and waveforms as are needed for the installation, calibration, maintenance, and repair of individual units. Except where the functioning of circuits would be adversely affected by long leads, test points shall be accessible on the front panels or immediately behind the access doors of all units. Test points necessary for alignment and adjustment purposes shall be provided at the front of plug-in cards and shall be accessible without a card extender. All test points shall be identified with a TP number; and, where space permits, the voltage value, signal waveform, or descriptive title (if voltage value or waveform would not be particularly significant) shall be on each schematic and/or logic diagram. Only descriptive titles or voltage values shall be shown for test points on exterior front panels. Suitable plastic cards shall be used to illustrate interior waveforms where the specified methods of interior marking are impractical. The equipment shall be designed to provide for connections of such test equipment as may be required for its installation, maintenance, calibration, and repair. Connection of test equipment to the test points shall not degrade system performance. Short circuiting to ground of any points shall not cause equipment component failures.

3.9.3.2 Diagnostic Software.- An integrated diagnostic software system shall be provided for the central processing module, the memory system and memory management unit, all I/O channels and interfaces, all peripheral equipment, the DDAS subsystem and the DEDS subsystem. The software shall be run while the system is off-line and shall provide diagnostic outputs in easily usable form. The diagnostic software shall be capable of isolating malfunctions to the lowest order replaceable module level for electronic equipment. Each diagnostic program provided shall exhibit the following characteristics:

(a) A single diagnostic shall be provided to isolate any and all failures within the system to indicate which of the three subsystems (DPS, DDAS, or DEDS) caused the failure indication.

(b) Additional individual diagnostic programs shall be provided for each of the three subsystems (DPS, DDAS, OR DEDS).

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(c) Each diagnostic program as defined in b. above, shall detect 95 percent of all single non-intermittent failures.

(d) Within the requirements of c. above each program and associated maintenance aids shall isolate 75 percent of all detected PCB failures within each subsystem to a replacement statement as defined below for mixed or unmixed card sizes:

(1) For PCB card sizes of 3 inches by 4 inches, or equivalent area or smaller, the failure shall be isolated in a replacement statement which shall identify not more than 5 PCB's.

(2) For PCB card sizes larger than (1) above, but less than 5 inches by 7 inches or equivalent area, the failure shall be isolated in a replacement statement which shall identify not more than 2 PCB's.

(3) For PCB card sizes larger than (2) above, the failure shall be isolated in a replacement statement which shall identify one PCB.

3.9.3.3 On-Line Test Pattern.- A test pattern shall be provided in the operational program which may be called up for display on the maintenance monitor while all other displays and system elements are being used for normal on-line ATC operations. This test pattern shall be suitable for use in display alignment and elementary system troubleshooting. The contents of the pattern shall be sufficient to provide for display alignment without need to reference any external special test equipment.

3.9.3.4 Off-Line Maintenance Requirements.- The system shall be designed to be isolated from interaction with the radar/beacon video equipment. Specifically, each individual equipment must be capable of being disconnected and power cycled on and off without causing failure of the display of radar/beacon video. The peripheral modules (e.g., keyboards, display control panels, beacon remote control boxes, RADS, and System Monitor Console) must be connected into the system via quick-disconnect plugs so that they may be removed and replaced with a minimum of down time. Each module shall contain all required maintenance indicators and controls to satisfy the maintainability and reliability requirements specified herein.

3.9.3.5 Maintenance Adjustments.- Maintenance adjustments in the form of easily accessible screwdriver adjustments shall be provided for the adjustment of display equipment operating parameters where such adjustment is required.

3.9.3.6 Automated Test Equipment.- ARTS IIA printed wiring boards (PWB's) will be repaired at the FAA Depot using FAA owned Genrad model 2272 automated test equipment. Test fixtures and test software used to repair ARTS IIA PWB's shall be compatible with the FAA owned Genrad 2272. The ARTS IIA test fixtures and test software shall allow PWB repair to the component level.

3.10 Capacity.- The capacity of ARTS IIA to process, store, and update targets using the ARTS IIA software in the TRACAB and TRACON configurations including the Dual CPM/Dual Sensor configuration shall be as described in the following table. The required capacity shall be achieved while updating 11 displays with the data load evenly distributed.

Total Target Capacity	256
Full Data Blocks	102
Associated Tracks (Mode-C)	102 (90)
Limited Data Blocks	61
Arrival/Departure Tabular List	93
System Data List (Lines Per Display)	12
Coast/Suspend List (Lines Per Display)	12
MSAW/CA Alert List (Lines Per Display)	5

3.10.1 Display.- Display capacity shall be as specified in Section 3.6 of this document. Required display capacity shall be met on all ranges and shall be independent of display center and target and data positions. All fields shall be assumed to be selected and all LDB's shall be assumed to be Mode C equipped and within the altitude filter limits. All LDB's shall also be assumed to be displaying 3/A read-outs. The system software and hardware shall have sufficient dynamic flexibility so that at any given time the data model as specified in Section 3.6. can be exceeded in a number of data types provided that there exists corresponding proportional reductions in other data types.

3.11 Response Time.- The ARTS IIA System shall be capable of operating with response times as follows:

(a) Changes in aircraft input data must be reflected on the controller's display within 1.5 seconds average after they are received at the system input interface (DDAS, interfacility, etc.).

(b) Changes in controller display data due to controller action such as quick-look, filter override action, change in selected codes, read-out requests, change in Mode C limits, range changing, off-centering, etc., shall be evidenced on the display within 1 second of the time the input action is completed by the controller.

(c) There shall be no perceptible lag in PEM marker movement, movement of sweep origin, range marks, map and other analog data.

(d) There shall be less than 250 msec delay between the time a keyboard key is depressed and the time the character reflected by that key is presented in the preview area.

The above requirements shall be met while processing data loads as required by Section 3.10, of this specification and updating eleven displays (one DBRITE and ten IFR room). For the Dual DPS/Dual Sensor system the capacity requirement of 3.10 shall be met for each subsystem.

3.12 General Requirements.- Equipment specified herein shall conform with the requirements of FAA-G-2100e and subsidiary applicable documents referenced therein, except off-the-shelf equipment as defined in 3.1. Nonconformance with FAA-G-2100e of the off-the-shelf equipment does not relieve meeting all other requirements stated herein, e.g., RFI integrity, environmental operating conditions, reliability, system performance, system capability, functional capability, maintainability, acoustic noise, wire connection methods, etc. All equipment, including off-the-shelf equipment, shall meet the general requirements specified below.

3.12.1 Mechanical Design.- Structural strength and rigidity of equipment units and cabinets shall be such that normal handling in loading, shipping, unloading, and setting into position for installation will not result in any permanent set or deformation sufficient to impair the appearance of the cabinets, equipment, or units, to interfere with ease of maintenance, removal of units or components, ventilation, or operation of access doors. The structural strength and rigidity of cabinets shall be independent of any strength and rigidity furnished by access doors. The design shall provide good accessibility for maintenance and repair of units, components, circuits, as well as a neat and pleasing appearance. Each unit shall be removable from the front or rear, as appropriate, of the cabinets without requiring the partial or complete removal of any adjacent unit. Cabinets shall be of high quality, sturdy construction, and be accurately and carefully fabricated. All cabinet assemblies shall be designed so that it will not be necessary to bolt or fasten down the equipment; however, facilities to bolt or fasten down cabinets shall be provided. All access doors shall be mounted by slip-pin hinges so that doors may be removed easily from the cabinets. Panels and chassis shall be adequately braced and of sufficiently small size and weight to permit removal and replacement for repair or for interchanging of units. Where equipment cabinet lifting devices, such as hooks or rings, are installed for the convenience of handling, such devices shall be replaced by the contractor with suitable painted cap bolts to be inserted after removal of such hooks or rings. Full access doors shall be provided for all cabinets in the equipment room. All equipment room cabinets shall be designed for installation side-by-side with no open space between cabinets. The contractor shall use ferrous metals (steel) for the construction of equipment cabinets. Exception: Any rack panels shall be aluminum. For the RADS and other new cabinet/box design units (A/N Panel, Display Control Box, etc.), the contractor shall use QRCQ 1009 per QQ-S-698. Plates, brackets, bars, etc. shall be in accordance with QQ-S-741. Any off-the-shelf cabinets used (i.e., DDAS/DPS; existing cabinet designs) shall be made of CR steel, commercial quality, which meet the requirements of CRCQ per QQ-S-648.

Preparation for finishing shall be in accordance with TT-C-4903 Method III, Type III. Final finishing shall be in accordance with FAA-E-2570C and FAA-G-2100e.

If the contractor elects to use ferrous metals (steel) on this contract for the above, he is not in any way relieved from setting all performance requirements as would be expected when using non-ferrous metals (aluminum). Cabinets may be designed to be installed adjacent to a partition or wall, providing that there is full access to all equipment within the cabinet without requiring the partial or complete removal of the cabinet or of any adjacent unit.

Convenience twin outlets in accordance with 3.3.2.1.7. of FAA-G-2100e shall be provided on the front and rear of each cabinet and display console for 120 volt AC test equipment, soldering irons, etc. The ground terminal of all convenience outlets shall be grounded. If individual cabinets are bolted together in a normal installation, each cabinet in turn shall contain convenience outlets, one in the front and one in the back.

3.12.1.1 Color and Texture of Finishes.- The finish of all exposed covers, doors, shells, etc., in the equipment room shall be baked vinyl. Accent panels shall be in contrasting colors. The basic color and accent panel colors shall be as specified by the Contracting Officer from the colors normally offered by the manufacturer. All control panels shall be of the finish normally supplied for commercial applications. However, if plastic control panels are to be used, samples of each plastic control panel type shall be submitted for Government approval.

The finishes of existing cabinets and consoles shall be retained. Modifications of the existing cabinets or consoles which result in new exterior surfaces, excluding new devices, shall be painted to match the existing finishes.

In the operating area, the front face and edges of exterior and interior front panels and panel doors, and the exterior surfaces of console cabinets, portable cabinets, and all other exterior metallic enclosures, including the doors thereof and exterior and interior trim strips, shall be finished as follows:

(a) Metal surface shall be prepared in accordance with the applicable requirements of FAA-STD-012A.

(b) Epoxy polyamid primer per MIL-P-2377, Class I, Thickness 0.0006 to 0.0009 inches.

(c) One or more coats of synthetic urea enamel made by Andrew Brown Company per Federal Standard 141A, Method 6103 or equivalent, color brown, color number 30372 per Federal Standard 595A Thickness 0.0009 to 0.0013 inches.

3.12.1.2 Ventilation and Cooling.- All blowers, vents, and cooling equipment necessary for the proper ventilation of the equipment shall be provided. Each cabinet requiring forced ventilation shall contain its own blower system and shall require no external ducts. The design shall be such that with access doors and/or plates open for up to 8 hours for servicing, the equipment shall not overheat or develop hot spots exceeding the allowable temperature rise. The heat generated by each system module shall be specified in the proposal.

Ventilation exhaust shall be from the top of the cabinets. Ventilation exhaust outlets shall be designed so that foreign objects dropped from above can not enter the cabinet through the exhaust openings.

3.12.1.3 Audible Noise for Remote Units.- Any modification made to existing equipments shall not cause any increase in the existing equipment room noise level at any frequency in the audible range. ARTS IIA equipments that are installed under the contract shall meet the noise requirements of FAA-G-2100e paragraphs 3.3.1.3.1 and 3.3.1.3.2.

3.12.1.4 Size, Weight, and Floor Loading.- Equipment specified herein shall be constructed to be installed in the space provided. The back room equipment (all system equipment excluding the operational display consoles) shall be located in a common area. The backroom equipment for an ARTS IIA in a TRACAB configuration (with three operational and one maintenance display) shall be capable of being installed in a 100 square foot area including sufficient space for test equipment usage and storage.

The maximum dimensions of the equipment room cabinets shall be 72 inches in height, 37 inches in width, and 30 inches in depth.

Floor loading shall not exceed 100 pounds per square foot on a distributed basis.

3.12.1.5 Air Filters.- The air filter for the cabinets shall be attached to the inside of the rear access door in a manner that provides easy and quick removal and replacement.

3.12.1.6 Overheat Warning Devices.- The methods used for overheat warning on the existing GFE equipment shall be retained.

For each new equipment rack or cabinet added, a thermal warning device shall be provided to indicate when the temperature reaches a maximum safe upper operating limit. For this purpose, a conspicuously placed readily visible warning light shall be located on each equipment rack or cabinet and an audible alarm shall be provided in each rack or cabinet, or a common audible alarm system for all new equipment may be provided. The audible alarm shall be activated when any of the warning lights are energized. A manual override switch shall be provided to by pass the audible alarms. A thermal over-temperature circuit shall be provided in each equipment rack to remove power when the temperature approaches a point at which equipment damage will occur.

3.12.1.7 Castings.- All castings shall be sound, dense, and free from casting defects.

3.12.1.8 Dissimilar Metals.- Dissimilar metals indicating an electrolytic potential difference greater than 0.4 volt when immersed in a 3 percent sodium chloride solution shall not be used in intimate contact unless suitably protected against electrolytic corrosion.

3.12.1.9 Moisture Pockets.- The equipment shall be constructed so that there are no pockets, wells, traps, and the like in which water and condensed moisture can collect when the equipment is in the normal operating position.

3.12.1.10 Gear Assemblies.- Gear assemblies shall be properly aligned and meshed and shall be operated without interference, tight spots, loose spots, or other irregularities. Where required for accurate adjustment, gear assemblies shall be free from backlash.

3.12.1.11 Bearings All bearings shall be permanen / sealed and lubricated.

3.12.1.12 Packaging.- The basic concept of system packaging shall be modular. Wherever practical, functional equipment groups shall be physically grouped within the equipment cabinets. The number of module types shall be kept to a minimum consistent with good design practices to keep the number of unused elements or spare modules to a minimum.

Plug-in components should be standardized as to size and function to the maximum extent possible. Accessible test points shall be provided to permit fault isolation to modular level.

3.12.2 Electronic Design.- All circuits shall be designed so that no damage will occur when the equipment is operated with the operating controls and maintenance adjustments set to any possible configuration of settings. No fuses shall blow with actuation of any operational controls.

3.12.2.1 Shielding and Isolation.- There shall not be any brightness level objectionable flashing, defocusing, distortion of sweeps, distortion of displayed data, extraneous data or spurious data, such as may be caused by switch operation, extraneous 60 hertz pickup in the equipment, extraneous 60 hertz pickup on the interconnecting cables, inadequate isolation from circuits incorporated in the equipment having high transient voltages and current, or any other electrostatic or electromagnetic pickup.

3.12.2.2 Reserve Circuit Card Capacity.- Reserve circuit card capacity shall be provided to accommodate a least 10 percent cards in each bin that the equipment requires.

3.12.2.3 "This section not used"

3.12.2.4 Location and Controls.- All controls shall be on the front surface of the panel of the unit with which the control is associated or immediately behind front access panel doors of each unit to minimize the possibility of personnel coming in contact with high voltages and components operating at high temperatures. Except for the RADS console and Alphanumeric Control Panel front panel surfaces, the contractor shall use a silk screen marking process with epoxy ink for marking on front panel surfaces. Controlled functions (such as gain and voltage) shall increase with clockwise rotation as viewed from the operation position. There shall be no noticeable lag between the actuation or adjustment. All controls shall have calibration markings to permit setting to predetermined positions, except where it can be demonstrated to the satisfaction of the Government that such compliance is impracticable or unnecessary. Motor driven switches and controls are prohibited. The range of operational controls shall not permit accidental burnings of CRT phosphor.

3.12.2.5 CRT Power Supplies.- All supply voltages to CRT's shall be designed at nominal values which shall be selected by the contractor to provide optimum performance. The regulation of all CRT power supplies, including anode, grid, and focus supply voltages, shall be such that no perceptible defocusing and/or change of intensity shall occur when the line voltage is varied through the service condition limits or when large blocks of saturated video signals are applied to the CRT. Video and sweep drive voltages to the CRT's shall be adjustable to provide optimum performance.

3.12.2.6 Power Supply Indicators.- Each circuit protected by a fuse or circuit breaker shall have an indicator lamp which shall be illuminated when the fuse (or circuit breaker) is open. Neon indicator lamps shall be used wherever this is possible. All indicator lamps shall be uniformly located with respect to their associated fuses or circuit breakers or they may be an integral part of the fuse holder assembly. However, the indicator lamp shall be replaceable without having to replace any other portion of the fuse holder assembly.

3.12.2.7 System Grounding.- A common system grounding design criterion shall be used for all subsystems to be delivered. The grounding design shall be submitted as part of the proposal.

The design must be compatible with other equipment with which this system will interface. Line filters, if used, shall not introduce currents in the signal grounding system. The grounding design shall be in accordance with FAA-G-2100e paragraph 3.3.2.6. All grounds shall then be bound together at a common point within each separately powered enclosure. All equipment ground wires shall be at least 500 circular mills per linear foot. A 50-foot wire would thus be 25,000 circular mills. The contractor shall be responsible for interfacing his system grounding with existing systems.

3.12.2.8 X-Ray Radiation.- X-ray protection shall be in accordance with paragraph 3.3.7.2 of FAA-G-2100e. The limit of paragraph 3.3.7.2 of FAA-G-2100e, shall apply when measured on the faceplate or filter of any display using CRT's, or any other tube, transistor, integrated circuit, or solid state device employing high voltage, or any high voltage component. Where such radiation shielding is required to maintain the radiation within the required limits, the instruction book shall include prominent notice of care to be exercised in opening shielded areas. This requirement is in addition to the interlocks and warning signs required by 3.3.7.5 of FAA-G-2100e.

3.12.2.9 Conducted and Radiated Interference.- Equipment specified herein shall satisfy the basic limit of interference and susceptibility as specified in Methods 3001, 3002, 4001, 5001, 5002, and 6001 of MIL-STD-826A (USAF). Should the proposed equipment have been built to comply with military interference control specification other than MIL-STD-826A (USAF) (e.g., MIL-I-16910C), the Government will accept that specification in lieu of MIL-STD-826A (USAF) provided that the requirements of the two specifications are generally comparable. If the proposed equipments have not been tested for compliance with any military interference control specification, actual experience may be substituted provided the proposed equipment or an earlier design having similar interference and susceptibility characteristics, demonstrates proper operation in an environment typical of FAA's. In any case, the contractor shall be responsible for the equipment not interfering with nearby equipment and for it not being adversely affected by external fields. The contractor should note that the prospective locale for each installation will be one that is subject to large amounts of radiated or conducted electrical interference energy. The equipment shall function satisfactorily under existing conditions at such a locale during normal operation and while being maintained. Sources for the electrical interference include radars, communications equipment display equipment, teletypewriter equipment, and similar devices.

3.12.2.10 Cable Le...chs.- The system design shall pe.mit location of equipment such that cable lengths will be less than 500 feet between equipments. System performance shall be met with any cable length up to 500 feet unless specifically noted otherwise in this specification. Interconnecting cables shall not be looped or rolled to obtain specific lengths.

3.12.2.11 Components and Materials.- Except for off-the-shelf equipment, selection of components and materials shall be in accordance with FAA-G-2100e. Off-the-shelf equipment may employ components or materials not in accordance with FAA-G-2100e except the interchangeability of subsystems, components, parts, and materials as specified in paragraph 3.5.4 of FAA-G-2100e shall apply. Standard components shall be identified with the original manufacturer identification, i.e., RETMA, JEDEC, etc.

3.12.2.11.1 Specification FAA-G-2100e.- Delete Paragraph 3.5.5.6.10 and substitute in its place the following:

The use of edge board printed wiring boards is permitted. When edge board printed wiring boards are used, the edge board connector shall be of the bifurcated bellows type. Also, the edge board printed wiring boards shall have a warpage less than or equal to 0.061 inches along the contact edge of the board and warpage of no more than 0.130 inches at the rear edge of the board when size is 12 inches X 13 inches or greater (warpage at the connector and rear edge of the board is defined as maximum deviation from a straight line extended from corner-to-corner along the board edge). Warpage control shall be maintained by use of a suitable stiffener such as stainless steel, with appropriate insulation, riveted near the contact edge of the board. Spacing between adjacent boards shall be such that the complete printed circuit board assembly (with components mounted) can be properly and easily mated and withdrawn from the connector with no interference from adjacent printed circuit boards. The contractor shall submit his specification for edge board printed wiring boards and edge board connectors, warpage tolerance to the FAA for review and approval.

3.12.2.12 Service Conditions.- Except for off-the-shelf equipment, equipment specified herein shall operate within the service conditions of paragraph 3.3.4.1 of FAA-G-2100e. The normal ambient temperature of the environment in which the equipment will be installed will be 30°C. Design center values of the primary power sources shall be single phase 120V, 60 HZ.

3.12.2.12.1 Environmental Requirements.- The off-the-shelf equipment that will not conform to FAA-G-2100e shall be able to perform satisfactorily on a continuous unattended basis under the following conditions:

(a) 0-7000 feet altitude above sea level

(b) 50-90°F temperature (intake air temperature)

(c) Salt atmosphere as encountered in coast regions

(d) 20 percent to 80 percent relative humidity

(e) No direct air conditioning shall be required

(f) AC power input - single phase 2 wire 120 volt ± 10 percent, 60 Hz + 2 percent.

All equipment shall be able to perform satisfactorily on a continuous unattended basis in a salt atmosphere as encountered in coastal regions.

3.12.2.13 Wire Connection Methods.- For all equipments including off-the-shelf equipments, the requirements of FAA-G-2100e paragraph 3.7.7. shall apply.

3.12.2.14 Cables.- The contractor shall furnish all inter-cabinet cables, cable connectors, terminal boards, etc., required for factory and site testing and installation of the equipment. This shall include any special purpose test cables or card extenders required for routine maintenance. Where patch panels or plugs are used in the equipment, the contractor shall provide adequate plugs or patch cables as required for normal system operations.

All cables and wires, harnessed or single shall be suitably protected against chafing. Such protection shall be independent of the individual wire or cable insulation or jacket.

Cable entrances and exits shall be designed such as to enable advantageous routing of the cables between units from the standpoint of accessibility, noninterference with operating personnel, and appearance of installed equipment. Preferably, cables shall enter and exit at the top of the equipment room cabinets. If the equipment to be supplied has cable entrances and exits at the bottom of the equipment cabinets, a suitable means shall be provided for routing cables from overhead ladders to these entrances in a concealed fashion. The contractor shall provide cable entrances and exists with cover plates.

All cables shall be supplied with connectors installed. Any special tools required for cable fabrication shall be furnished by the contractor as special test equipment.

3.12.2.15 AC Power Consumption.- The total power consumption shall not exceed 4.0 KVA for a typical system backroom equipment consisting of a central processor with 6 display I/O channel, 256K memory, System Monitor Console and Data Storage Subsystem. The total power consumption of the contractor's supplied display equipment including a complete set of data entry equipment shall not exceed 1.7 KVA per display.

3.13 Documentation.- The contractor shall provide all necessary services and material to develop and deliver documentation in the quantities and at the times specified by the contract schedule. Documentation shall be in accordance with the following specifications to the extent specified herein.

(a) FAA-STD-010b

(b) FAA-D-2494

(c) FAA-STD-002, with Amendment 1

(d) FAA-G-1210c

All documentation required shall be periodically updated to reflect the latest design level. In the event that documentation has been submitted to the FAA, appropriate errata/revision pages in the same quantity as the earlier submission shall be provided or the document updated in total if more than 10 percent of the document has been changed. All reproducibles furnished shall be of such quality as to permit the reproduction of every line and character on the reproduced copy. Reproducibles of the sepia type shall have a minimum background or field density (no burned or dark areas).

All documentation produced or updated by the contractor shall show the contract number conspicuously displayed on each document, including drawings, to facilitate identification and association with the contract.

Test procedures, test plans, and the system design data shall contain a cover sheet noting the revision level of the document and each page therein. Each page shall also contain a designator for revision level.

Documentation submitted under the contract shall be subject to Government comment and approval. Time allotted for such comment or approval shall be as noted in the schedule.

3.13.1 Management Reports.- Management Reports shall consist of three parts:

(a) Program Status.- This shall include a narrative of work progress during the reporting period in the areas of design, fabrication, test integration, installation, spares support, training, maintenance and documentation.

(b) Schedule.- This shall include PERT diagrams and milestone charts for the activities related to the contract. The status and scheduled for production shall be shown on a Line-of-Balance report. A modified PERT reporting system may be used subject to Government approval.

(c) Problem Areas.- This shall include the discussion and solution or progress toward solution of special problems in both the develop-ment, production, installation, and support functions.

(d) The initial management reports shall also include the below listed information; changes, and updates to this initial submitted information shall be furnished in succeeding reports.

1. Program Plan.- Submit an overall plan designed to encompass every aspect in the planning, design, documentation, fabrication, quality control, production, factory tests, delivery, installation, provisioning, and warranty service.

2. Program Performance Schedule and Control Procedures.-Provide a detailed work breakdown structure and program performance schedule(s) (with supporting narrative exploration) that reflects all of the significant activities/events, with related appropriate time phasing of each element of the breakdown

structure that must be accomplished to assure successful completion of the ARTS IIA system program. As a minimum, the following elements shall be included:

(a) Program schedule in bar chart/milestone format, divided into three main efforts as follows: prototype design, presubmission test and evaluation of prototype, and production: all subcontract efforts shall be integrated into the schedule.

(b) PERT chart, including critical path analysis, identifying critical components, and lead as specified in (c) below.

(c) Subcontractor schedule/listing, components they will supply, including critical items, their lead times, and methods of management control of the subcontractors.

(d) Explain in detail the control procedures intended to be exercised to assure expeditious completion of all activity related to the program and/or timely updating of the performance schedule. Include manpower resources, by numbers and types of skills required, for each phase identified in the program schedule of (a) above.

<u>3.13.2 Test Plan</u>.- The objective of this plan will be to show how the contractor will demonstrate compliance with the requirements of the specification, its referenced documents, the contract, and any amendments.

<u>3.13.2.1 Test Plan Content</u>.- The test plan shall be comprehensive, including all details necessary to assure that test procedures and testing will satisfactorily demonstrate equipment compliance with all functional, operational, electrical, mechanical, and reliability requirements. The test plan shall include both tests to be conducted at the contractor's plant prior to delivery and onsite following installation. The tests shall be prepared to minimize interference with the operation of existing facilities. The test plan shall include all tests necessary to prove compliance with the specified system design.

On a system basis, the plan shall include as a minimum the following:

(a) An overview of the contractor's quality assurance and test programs.

(b) Test description and purpose for each test. The description shall include a block diagram showing the system configuration and interfacing procedures for conducting each test of the series, together with the personnel necessary to perform the test.

(c) Designation of all test inputs required to conduct the test.

(d) Test output records including a description of required outputs, the types of equipment used to observe or provide the outputs, etc.

(e) A complete time sequenced schedule of events.

(f) Proposed dates for each test. The Government reserves the right to witness any or all tests conducted in accordance with the approved test plan.

(g) List and description of all software to be used.

If during a test the test methods or parameters, as agreed to by the Government, are found to be inadequately specified, they shall be amended and further approval by the Contracting Officer obtained.

3.13.3 Test Procedures.- The contractor shall submit test procedures and data sheets for each test activity defined by the approved Test Plan. Each procedure shall be a comprehensive document including all necessary details to conduct the test and verify compliance with all requirements. The format and contents of all input and output messages should be detailed. The Government reserves the right to have the test procedures modified or amended should they prove incomplete or inadequate during test.

3.13.4 Test Record Forms.- The contractor shall supply all other necessary forms such as test operator logs and reports to be used during testing.

3.13.5 Final Test Reports.- Upon conducting the applicable tests in accordance with the approved test plan and test procedures, the results shall be recorded for submission to the FAA. The test report shall contain a complete description of the test results. The test report shall contain, as a minimum, the information specified below:

(a) Copies of the test data sheets

(b) The performance of each equipment under test and whether it meets the system limits

(c) Functions that were tested

(d) Information as to whether the results of the tests are in agreement with the required reliability of the unit for system

(e) The quantity and type of spare parts needed to correct the errors of malfunctions

(f) A record of any engineering changes found necessary to correct design deficiencies

3.13.6 Installation Planning Report.- The contractor shall provide the Contracting Officer in accordance with the contract schedule sufficient technical information on the installation of the system in report form to permit its distribution to the field by the Government. The information contained in this report will be used by FAA field organizations and facilities to prepare the sites for system delivery and follow on installation and check-out activities. As a minimum, the report shall contain the following general and typical information.

(a) System block diagram with a short narrative general description of the functional capabilities and hardware subsystems.

(b) Typical floor plan layouts for control and equipment rooms. Information on equipment placement limitations, e.g., maximum distances between equipment comprising the system or new equipments and equipments already in place, shall be included.

(c) Detailed physical description of the equipment including physical size, weight, clearance factors, ventilation or airconditioning requirements, cable entry, and exit features, etc.

(d) Cable and duct/overhead ladder requirements. This section shall include such items as information on subsystem cable interconnection requirements, system cable connections to existing equipment, type, and quality of cables to be used, etc.

(e) System and equipment grounding requirements shall be stated.

(f) Any other technical or general information that will be required for Government field organizations in order to properly prepare a site for installation activities and which should be considered for proper installation, operation, and maintenance of the equipment.

3.13.7 Site Survey Report.- When required by the schedule a site survey shall be conducted to collect installation data and site facility measurements. Based on this site survey the contractor shall prepare a site survey report and submit this to the Government for review. The report shall cover such items as:

(a) Location of equipment in both the control area and the equipment room. Floor plan layouts of both rooms will be provided by the government.

(b) Cable routing and estimated length of cable runs.

(c) Type of cable routing, i.e., overhead ladders, floor ducts, etc.

(d) Location, size, and type of power panel in relation to other equipment.

(e) Location of radar/beacon interface unit in relation to other equipment.

(f) Information on doorway, stairwell, elevator clearances, and loading.

(g) Any other general information mutually agreed to between the Government and the contractor.

3.13.8 Software Development Plan.- The contractor shall develop a Software Development Plan that shall detail the software development activities required to design, develop, test, adapt and implement the ARTS IIA software. The Software Development Plan shall include but not be limited to the following:

(a) An Introduction describing the plan and summarizing its elements.

(b) A Phase Plan describing the software development cycle.

(c) An Organization Plan describing the contractor's specific plans for organizing the ARTS IIA software development.

(d) A Documentation Plan that defines all the documents to be provided.

(e) A Change Control Plan that defines the documents to be controlled and describes the methods for making changes in these documents.

(f) A Review and Reporting Plan describing how ARTS IIA software development status will be reported to the government.

(g) A Resources and Deliverables Plan describing the resources required to implement the Software Development Plan and a summary of schedules and project milestones.

3.13.9 Index of Drawings and Technical Memoranda.- The contractor shall maintain an index of all drawings and technical memoranda in connection with design, fabrication, and test of the system.

3.13.9.1 Drawings and Technical Memoranda.- When requested by the Government, the Contractor shall provide and deliver copies of any interim drawings or technical memoranda produced in connection with the design, fabrication, and test of the equipment.

Drawings and technical memoranda produced in connection with the design and fabrication of off-the-shelf items which are in existence at the date of contract need be submitted only on a one time basis with the first index. The contractor shall provide drawings or technical memoranda that may be requested by the Contracting Officer as listed by any index furnished in accordance with this equipment.

3.13.10 System Design Data.- The design data submission shall be organized to reflect the contractor's approach to the total system design and shall be organized in a logical sequence to reflect the design approach. All pages shall be sequentially numbered. This submission of design data shall not be used to produce modifications or alternatives to details of this specification or a change in the scope of the contract. The design data shall include all elements of the equipment to be supplied by the contractor under the terms of the contract, as detailed by this specification and any addenda thereto, together with all interfaces with other equipment. A summary of equipment operational characteristics shall be included. This also applies to the items below.

3.13.10.1 System Description.- The System Description shall include a description of the overall system and each subsystem detailing the interaction and operational capabilities necessary to meet functional requirements.

3.13.10.2 Block Diagram.- A complete set of equipment block diagrams shall be provided by the contractor. The block diagrams shall show the general operational, electrical, and physical relationships of the equipment elements.

3.13.10.10.3 Information Logic Flow Diagrams.- The contractor shall provide complete equipment information logic flow diagrams. These diagrams shall show the detailed logical, operational, and functional relationships of the equipment elements. Symbology used in these diagrams shall be fully explained in the basic document.

3.13.10.4 Input/Output Details.- The contractor shall provide data which consolidates all equipment interfaces and input/output characteristics. This shall include: transmission line characteristics, signal characteristics and limits, timing diagrams, message structure and formats, and power requirements. This data shall include all major intra-system as well as external system interfaces.

3.13.10.5 Computer Program.- A complete description of the program organization and design specification, subprogram description, external data formats and internal data formats shall be furnished as part of the System Design Data for all software required by the contract schedule. The document shall provide overall information about the total computer program. The design specification shall indicate the partitioning of the functional requirements into logically related subsets which are identified with specification subprograms. For each subprogram a discussion of performance requirements including estimates of program timing and core storage shall be provided.

3.13.10.6 Mechanical/Electrical.- The design data shall include sufficient drawings and text to provide a description of major and critical dimensions, routing of cables mechanical assemblies and other major features such as: cable entry and exit, control, and maintenance panels. Power requirements shall also be provided.

3.13.10.7 Reliability/Maintainability.- Calculations of the reliability and a discussion of the maintenance philosophy per sections 3.8 and 3.9 of this specification shall be provided.

3.13.11 Hardware Design Data.- The Hardware Design Data shall describe how the hardware functional requirements specified in the System Design Data will be implemented. It shall provide a detailed functional design of each hardware element at a level that describes hardware systems operation and pertinent design characteristics. It shall describe in detail the system inputs and outputs, the functions to be performed by each element and the interface between modules. In addition, the following subjects shall be addressed: equipment physical characteristics, cooling and power requirements, maintenance approach, human factors considerations, control panel layouts, electrical signal levels, integrated circuit families, chassis design, packaging methods, interconnection methods, applicable environmental conditions and any other pertinent design characteristics required to fully describe the system hardware.

3.13.12 Computer Program Documentation.- The contractor shall provide all documentation necessary for the FAA to maintain and modify all deliverable ARTS IIA computer programs. The organization of all documentation shall be complete and conform to accepted program documentation practices. If similar commercial grade documentation is already available, even if in somewhat different form from that required they may be submitted for Government approval. This may obviate the need for some special publications.

<u>3.13.12.1 Operational Program Documentation</u>.- The operational program documentation shall include Computer Program Functional Specifications, Software Design Data, Coding Specifications, a User's/Operator's Manual, and a Software Maintenance Manual.

<u>3.13.12.1.1 Computer Program Functional Specification</u>.- The Computer Program Functional Specification shall describe in detail the functions which the ARTS IIA software performs. It shall describe functional requirements, inputs, outputs, error conditions and adaptation, performance and data base requirements. The CPFS shall conform to the format of NAS-MD-903.

<u>3.13.12.1.2 Software Design Data</u>.- The Software Design Data shall describe how the software functional requirements defined in the Computer Program Functional Specification will be implemented. The design shall be done in sufficient detail that all logic conflicts are resolved. Program modules are described in terms of the functions they must perform and the interfaces it must have with other modules, but the detail design of these modules is left to the Coding Specification. In addition, the following subjects shall be addressed: all internal and external interfaces shall be defined, system files and data base elements are laid out, program module connecting logic is defined, data flow through the modules is described, and module storage and timing requirements are estimated. The Software Design Data shall conform to the format of Part II of the Computer Program Functional Specification NAS-MD-903.

<u>3.13.12.1.3 Coding Specification</u>.- The Coding Specification shall provide an overview of all program elements and their interrelationships to the hardware to describe how the functional requirements of the system are met. It shall describe the logical design of each program module and shall provide sufficient detail to allow FAA personnel to maintain and make program modifications. The manual shall include but not be limited to the following:

(a) The manual shall specify the procedures for maintaining and updating itself and identify the relationship of this manual to the other software documents.

(b) The manual shall provide a detailed explanation of conventions adopted within the operational program with respect to program design language, table names, data names, routine labels, and calling sequences

(c) The manual shall provide a detailed explanation of hardware related programming factors such as input/output formats, codes, bit arrangements for control characters, communication sequences, and interrupt processing.

(d) The manual shall describe how adaptation parameters are modified for individual sites and for different subsystem sizes and shall include parameter nominals, range increment, and effect.

(e) The manual shall provide for each subprogram within the operational program, a narrative description, specification of the program inputs, outputs and their definitions, system functions performed, and the specific method employed. The contractor shall provide specifications in this section showing table definitions, storage allocation, and identification of reserved registers. For each subprogram, the contractor shall provide detailed Program Design Language which shall describe in detail those subprograms within the system program which create input for it or receive output from it.

(f) The manual or supplementary documents shall provide complete program listings.

3.13.12.1.4 Users'/Operators' Manual.- A Users'/Operator's Manual which provides an operator with an understanding of the system configuration and with all of the information needed to operate the operational programs shall be provided. The manual shall clearly describe the relationship of the manual to other program documentation, identify procedures for updating the manual, describe the location and function of all operation controls, describe use of all peripheral equipment, indicate system error printouts, and provide detailed operating procedures for both normal operation and failure modes.

3.13.12.1.5 Software Maintenance Manual.- A Software Maintenance Manual shall be provided that describes the procedures required for FAA personnel to maintain the ARTS IIA operational and off line software. Included shall be procedures for patching, assembling, compiling, linking, loading and building the ARTS IIA software. Software tools including the DOS operating system, assembler, compilers, utilities, editors etc. shall be described and procedures for their use in software maintenance shall be discussed.

3.13.12.2 Non-Operational Program Documentation.- This documentation shall include a utility program reference manual (assembler, compiler, loader, dump, etc.) a programmer reference manual; reference manual for the diagnostic and maintenance software and listings and program copies of all non-operational programs as specified elsewhere.

3.13.12.2.1 Utility Program Reference Manual.- This manual should indicate all actions required to prepare, initiate, run, and analyze output of programs for assembly or compilation. In addition, the use of other utility software such as debuggers, dumps, loaders, flight plan file editors, etc., shall be clearly described. The manual should be sufficiently detailed to allow programmers to analyze all listings, evaluate error conditions, and in general, produce complete programs.

Also to be included are appropriate flow diagrams or program design language and instructions to permit operation, maintenance, and program modification for the compiler, assembler, loaders, linkers, editors, dumps, and other support software.

3.13.12.2.2 Maintenance Program Reference Manual.- Complete documentation of all diagnostic and maintenance programs (including deliverable system test programs) including initiation and intervention procedures, a complete list of possible error halts, and all possible actions and procedures required of the operator or maintenance personnel shall be provided.

Also to be provided are appropriate flow diagrams and instructions to permit maintenance and modification of these programs.

3.13.12.3 Programmers Reference Manual.- A Programmer's Manual which includes a description of the computer instructions, commands, and orders used in an operational machine program, shall be provided. The manual shall also include, but not limited to, information on instruction timing, use of index registers, logical and arithmetic operations, data transmission, input/output operation, use of indicator lights and branch switches, and data necessary for the use and control of programs.

3.13.13 Reliability/Maintainability Report.- The contractor shall prepare and submit a Reliability/Maintainability report containing a complete detailed analysis of the equipment reliability and maintainability and a summary of this program.

Included as part of the monthly report shall be a problem or "weak link" chart containing a list of problems, the person or agency to whom the problem is assigned, the date assigned, estimated date of completion, date of completion, action taken, and the numerical effects, if any, on reliability and maintainability.

3.13.14 Test Equipment List

3.13.14.1 Special Tools and Test Equipment.- The terms special tools and test equipment is defined as those tools and test equipment not carried as a standard line by the contractor or another manufacturer. All special tools and test equipment necessary for the installation, repair, adjustment, test and maintenance of the system specified herein, not readily available on the open market, such as alignment wrenches, testing devices, jigs, special purpose test cables, circuit card extenders, etc., shall be supplied with the equipment. The contractor shall submit for Government review a complete list of special tools and test equipment, the application of each, and unit and/or component for which it is required. This shall be submitted prior to fabrication or procurement of any specialized tools and test equipment for use at Government facilities. The design of the equipment shall be such as to permit the use of standard tools and test equipment insofar as practicable.

Card extenders shall be supplied as required special test equipment. One card extender shall be supplied with each system. This requirement is in addition to any printed circuit board extender of other types which are necessary to diagnose failures or maintain the system.

3.13.14.2 Standard Test Equipment.- The contractor shall provide a list of standard test equipment which will be required, as a minimum to maintain the system. The information in this list shall include but not be limited to the following for each item of test equipment.

(a) Intended use, e.g., measure volts, count pulses, etc.

(b) Ranges required

(c) Accuracy requirements

(d) Special parameters, e.g., short term drift, long term stability, temperature requirements, etc.

(e) At least three suggested sources of supply

(f) Estimated cost (catalog prices) for single units and quantities

(g) Estimated frequency of use

3.13.15 Maintenance Instruction Manuals.- These books shall be of sufficient depth to permit FAA maintenance and operation of the equipment. They shall include material on theory of operation, operating instructions, maintenance instruction (including a complete set of block and schematic diagrams) circuit diagrams, parts and test equipment list, and instructions for running and evaluating the results of diagnostic, maintenance, and test software. All equipment Maintenance and Instruction Books shall be provided in accordance with FAA-D-2494. Engineering drawings shall be in accordance with FAA-STD-002, with Amendment 1. Graphic symbols for digital logic diagrams shall be in accordance with FAA-STD-010b.

3.13.15.1 MIL-STD-806B

(a) Delete paragraph 3.4.1.

(b) Delete paragraph 3.4.2 and insert the following in its place:

"3.4.2 The logic hardware identification shall be located immediately outside the logic symbol representation, except where logic symbol drawing size clearly facilitates inclusion of logic hardware identification inside the logic symbol (i.e., oscillator)."

3.13.16 Hardware User's Manual..- The Hardware User's Manual shall be provided for all non-operational test and support equipment. It shall provide user's and maintenance information similar to, but but less detailed than the Maintenance Instruction Manuals described in paragraph 3.13.15. The manual shall provide as a minimum the theory of operation, functions of control panel indicators and switches, printed circuit assembly schematics and layouts, logic drawings, timing diagrams, schematics and interconnect drawings. The manual shall also include a reference to supporting information such as other user's manuals and applicable portions of design data or coding specifications. Any applicable diagnostics, test software, or vendor manuals for COTS equipment useful for maintenance shall be included.

4. Quality Assurance Provisions.- The following levels of inspection and testing are applicable to the ARTS IIA systems and shall be conducted in accordance with the requirements put forth in the contract. The quality assurance provision of FAA-G-2100e form part of this document and shall be complied with, unless otherwise specifically noted. A Quality Assurance Program shall be established and implemented in accordance with the contract.

Records of tests, including examinations and inspections shall be kept complete and available to the Government. All tests and inspections shall be performed by the contractor. The Government, however, reserves the right to witness or perform any of the tests or inspections required. The Government reserves the right to subject all tests and inspections to Government approval by FAA inspectors. The Government also reserves the right to waive the requirements of any portion of the inspections and tests. All tests shall be conducted in accordance with the test methods and procedures stated in the Government-approved Test Plan.

The contractor shall be responsible for conducting all required tests. Whenever testing is scheduled, the contractor shall ascertain that all necessary personnel are available, that test scripts and test data sheets have been distributed, and that the test area has been cleared of all equipment parts, components, etc., not required for the subject test. All test personnel shall normally be provided by the contractor. However, the FAA reserves the right to use FAA personnel in lieu of contractor personnel to man any operating position in the equipment configuration under test. The contractor shall make any and all additional tests necessary to demonstrate compliance to the required system performance. If during the course of any tests, errors, or malfunctions occur, the contractor shall title the appropriate forms and make entries in the appropriate logs. In addition, the contractor shall document each error or malfunction indicating the type, the procedure taken, the time required to circumvent, and the assignment to the appropriate equipment or software element.

The contractor shall be responsible for incorporating and testing any modification to his design found necessary during the testing of the equipments. No design changes or modifications will be allowed to the equipment under test without the approval of the contracting officer. If any changes are found to be necessary, the Government reserves the right to require any completed tests to be re-run to verify that no adverse effects result from the change. Failures during testing shall be recorded in accordance with the Facility Outage and Equipment Failure Report (FAA Handbook SMP 6040.1B). Maintenance logs shall utilize FAA Form Form 6030.1 and be filled out per Order 6000.15A. The FAA may require the contractor to repeat tests, or portions thereof, if the original tests fail to demonstrate compliance with the specification.

4.1 Incoming Inspection.- The contractor shall perform incoming inspection at the production site on all materials and components used in the construction of the equipment to assure specification conformance. Incoming inspection may be monitored by FAA personnel. All microelectronic devices (except those used in off-the-shelf equipment as defined by the specification) shall be inspected and tested in accordance with MIL-STD-883 screening method J5004, class B screen level, or equivalent as approved by the Contracting Officer. Inspection and testing of microelectronic devices may be accomplished by the device vendor, provided his product assurance program for devices to be used on this contract are in accordance with requirements of MIL-M-38510A, or equivalent and such programs have been approved by the Contracting Officer. The contractor shall submit vendor inspection reports to the Contracting Officer to verify that required microelectronics inspections have been performed.

4.2 Subsystem Inspection.- Subsystem inspection shall consist of an electrical and mechanical examination of each subsystem and the units contained therein. The mechanical examination shall be used to determine compliance with the applicable specifications covering fabrication requirements such as rigidity, strength, accessibility, type of materials and components, choice of insulation, layout of chassis, panel, and wiring, etc.

Electrical inspection shall determine compliance with the applicable specifications covering electrical requirements and performance, such as electrical continuity, leakage resistance, power supply voltages and regulation, signal-to-noise ratio, pulse and wave shapes, resolution, storage characteristics, etc. Units built, tested, and approved in accordance with the applicable specifications may be retained temporarily by the contractor in order to facilitate testing of associated units; however, such units used for test purposes shall be given a mechanical and electrical re-inspection prior to Government acceptance if required by the Contracting Officer.

4.3 Subsystem Functional Test.- Functional tests shall be tests on a subsystem level to verify the functional requirements and interfaces of the DDAS, DPS, DEDS and sub-assemblies therein. Such tests shall use hardware simulators and internal diagnostic software to verify that each unit is capable of operating in conformance with its functional requirements when integrated into a system. These tests shall be conducted on those units called out by the contract schedule.

4.4 Factory System Test.- Those systems designated in the contract shall be assembled and tested as a system at the contractor's plant. The contractor shall demonstrate conclusively that all specification requirements are met on the system before shipment to the site. The factory system test shall be conducted using video inputs. The video inputs shall be derived from standardized simulated inputs to the system.

The Government will make available isolated video outputs from its operational beacon/radar systems at the FAATC, where practical, for program debugging, factory system integration, and other tasks which may be required prior to the official factory system test. The factory system test shall be conducted with the use of the operational software programs that are required for each system under the terms of the contract except for the specific site adaptation tables. However, simulated site adaptation tables shall be used to the extent necessary to reasonably distribute and display the simulated input targets on the displays that are being tested as part of the system. All equipments and software composing the system shall be operationally tested in accordance with Government approved, contractor-developed test plan.

4.4.1 Confidence/Stability Test.- As part of each factory system test, a continuous confidence/stability test shall be performed using video inputs with the operational program running. Manual inputs from the display data entry devices shall also be used. The contractor shall include in his test plan the proposed pass/fail criteria to be used and his recommendation on the length of time the test should run (minimum of 72 hours is required). This criteria should be consistent with the specified system reliability. Measurements shall be made at the beginning of the test and at specified intervals which shall be indicative of the stability of the system. All system adjustments shall be made prior to the start of the test and no further adjustments will be allowed for the duration of the test. During the last half-hour of the test, a simulated power failure test shall be made. This test shall be made interrupting all AC power to the system for a period of at least 15 seconds. When power is restored, all malfunctions or errors shall be recorded. The test shall be resumed without any equipment adjustments. If manual adjustments or intervention is required to re-initiate operation, these shall be fully documented in the test report.

4.5 Design Qualification Tests.- Design qualification tests in conformance with paragraph 4.3.2 of FAA-G-2100e and the following paragraphs in this specification shall be performed as required by the contract.

4.5.1 Reliability Test.- The reliability program and testing shall be conducted in accordance with MIL-STD-785 and MIL-STD-781. The contractor's staffing for the test shall be in accordance with the manpower requirements set forth in the maintenance philosophy and contract maintenance plan of his proposal. Equipment acceptance or rejection shall be in accordance with the criteria and failure definitions listed in Section 4.10.

4.5.2 Maintainability Test.- The maintainability test shall be in accordance with MIL-STD-471. Method 2 of that document shall be used as a guide to determine Mean Down Time. A sample of 50 maintenance actions shall be drawn from each subsystem (DDAS, DPS, PPI DEDS) Compliance will be based upon demonstration of a Mean Down Time less than or equal to that specified herein. The consumer risk B shall be 20 percent. The diagnostic programs of paragraph 3.9.3.2 shall be exercised as a part of this test to insure compliance with requirements of paragraph 3.9.3.2 and all other applicable paragraphs herein.

4.5.3 Service Conditions.- The service condition qualification test shall be performed on a system for which the contractor has specially supplied all maximum length cables. The system under test shall contain at least one and at least one PPI DEDS. The system shall be tested by the contractor over the controlled environmental service conditions listed in 3.12.2.12.

4.5.4 Functional Test.- This shall be a test (or series of sub-tests) to verify that all functional characteristics are in conformance with specification requirements. As part of this test system response time and capacity will be measured. Inputs for the response time and capacity test will be from a contractor furnished beacon video simulator and/or Test Target Generator. The system capacity and response time tests shall demonstrate the following:

(a) Ability to accept and process targets and tracks at the maximum specified rate

(b) Ability to simultaneously update each DEDS with the maximum data load imposed by paragraph a. above.

(c) Continue normal operation of the system (interfacility message transfers, controller message input, etc.) during Conditions a. and b. above

The test shall then continue until data loads 33 percent in excess of those required are imposed upon the system. The type and nature of system degradation shall be noted. Because of the nature and complexity of the design qualification test of functional requirements, it may be more efficient to perform qualification of some areas on a subsystem rather than on a system level. The contractor's test plan should consider the cost, schedule, and technical tradeoffs in this area and propose the most efficacious scheme to complete functional design qualification in all areas.

4.6 Type Tests.- Subsystem environmental type tests shall be conducted as required by the contract schedule in accordance with paragraph 4.3.3 of FAA-G-2100e.

4.7 Onsite Acceptance Tests.- The contractor shall conduct onsite acceptance tests on each ARTS IIA system. The onsite test shall be performed to the same subsystem or module level as the Factory System Test. The contractor shall demonstrate system operation in compliance with all design requirements. Contractor responsibilities relating to such items as briefings, logging of test malfunctions, distribution of procedures, etc., shall be as noted in Section 4 herein. System site tests shall verify system operation in compliance with all design requirements. These tests shall be conducted in three stages:

4.7.1 Stage 1.- Stage 1 shall verify system integrity prior to interfacing with any site equipment. Stage 1 must be successfully completed before Stage 2 can be started.

4.7.2 Stage 2.- Stage 2 shall be an integrated test to be conducted after the system is integrated with the site facilities. To minimize interference with the normal facility operations, this test shall be conducted with the DEDS in a test bed configuration where the normal videos, triggers, and azimuth information will be made available. The system performance shall be demonstrated utilizing the operational computer program. The System performance demonstration shall require not less than 72 hours of continuous operation as a confidence stability test before proceeding into Stage 3. As many DEDS shall be utilized in this demonstration as space requirements shall allow but not less than one DEDS of each type shipped to each site shall be required.

4.7.3 Stage 3.- This stage shall use all operational displays to demonstrate complete site adaptation. During this test all functions and combinations of functions such as keyboard and trackball data entry, tracking, display processing, etc., shall be exercised to show conformance with each of the systems operating requirements.

4.8 Classification of Failures.- There are two major classes of failure: relevant (countable) failures and non-relevant (non-countable) failures. Relevant failures affect performance parameters and are defined as:

(a) Manufacturing defects

(b) Parts defects

(c) Design defects

(d) Unknown

Failures due to other causes will be classified non-relevant. This class includes failures due to:

(a) Accident or mishandling

(b) Operator (where not due to improper design)

(c) Failure of part not supplied by the contractor

(d) Test equipment or facility failure

(e) Maintenance induced failure

(f) Installation error

(g) Drawing specification or procedure error excluding diagnostic procedures

The burden shall be on the contractor to show that a failure should be classified non-relevant. In the case of a non-relevant failure, the contractor shall inspect items such as documentation, procedures, etc., to determine whether clarification or correction of the items could reduce the risk of failure.

<u>4.9 Failure Reporting</u>.- Failures during system level tests (qualification tests, type tests, site acceptance tests or factory system tests) shall be recorded in accordance with National Airspace Performance Reporting System (FAA Order 6040.15). Maintenance logs shall utilize FAA Form 6030-1 and be completed in accordance with FAA Order 6000.15A.

<u>4.10 Accept/Reject Criteria - Reliability Qualification Test</u>.- The accept/reject for the reliability qualification test shall be in accordance with Test Level A-1, Test Plan IV, paragraph 4.2.8.4. of MIL-STD-781B dated November 15, 1967. Countable failures shall be relevant failures of the system as defined by Section 4.8. of this specification. During this test, the system shall be operated for the minimum amount of time required to satisfy both Conditions 1 and 2 below. The system shall be operated 24-hours/day, less preventive and corrective maintenance, 7 days/week during which time failures, duration of down times due to failures, and duration of preventive maintenance during factory tests shall be recorded. The schedule for preventive maintenance shall be the same as that recommended by the contractor for normal operation. In addition, no more than one preventive maintenance period per 24-hours of operating time is permitted with a maximum duration of 1 hour per any period of preventive maintenance. The reliability requirements shall be considered satisfied if, and only if, each of the following conditions are met:

<u>4.10.1 Condition 1</u>.- That an accept decision in accordance with Test Plan IV is reached.

<u>4.10.2 Condition 2</u>.- That the mean corrective time is less than or equal to 0.6 hours per 3000 hours of system operation. Time required for preventive or corrective maintenance during which all system units are not fully operable

shall not be countable toward operating time.

4.10.3 Condition 3.- That the mean preventive maintenance time is less than or equal to 1.4 hours per 1000 hours of system operation. Time required for preventive maintenance during which all system units are not fully operable shall not be countable toward operating time.

4.10.4 Criteria for Acceptance.- Failure to meet Condition 1 or the reaching of a reject decision shall require corrective action and restart of the test from zero time. If Condition 2 is not satisfied when Condition 1 is satisfied, the reliability test shall be terminated. Action shall be taken by the contractor to correct preventive and/or corrective maintenance deficiencies and the maintainability test specified in paragraph 4.5.2. of this document shall be conducted to demonstrate compliance of the revised corrective maintenance procedures. If Condition 3 is not satisfied when Condition 1 is satisfied, the contractor shall correct the preventive maintenance deficiencies and continue the reliability testing until all three conditions are satisfied. Satisfactory demonstration of Condition 2 during the reliability test shall not remove the requirements imposed by paragraph 4.5.2 of this document.

4.11 Notification of Readiness to Test.- The Government shall be given 10 working days notice of the contractor's readiness to start tests above the unit inspection level.

* * * * *

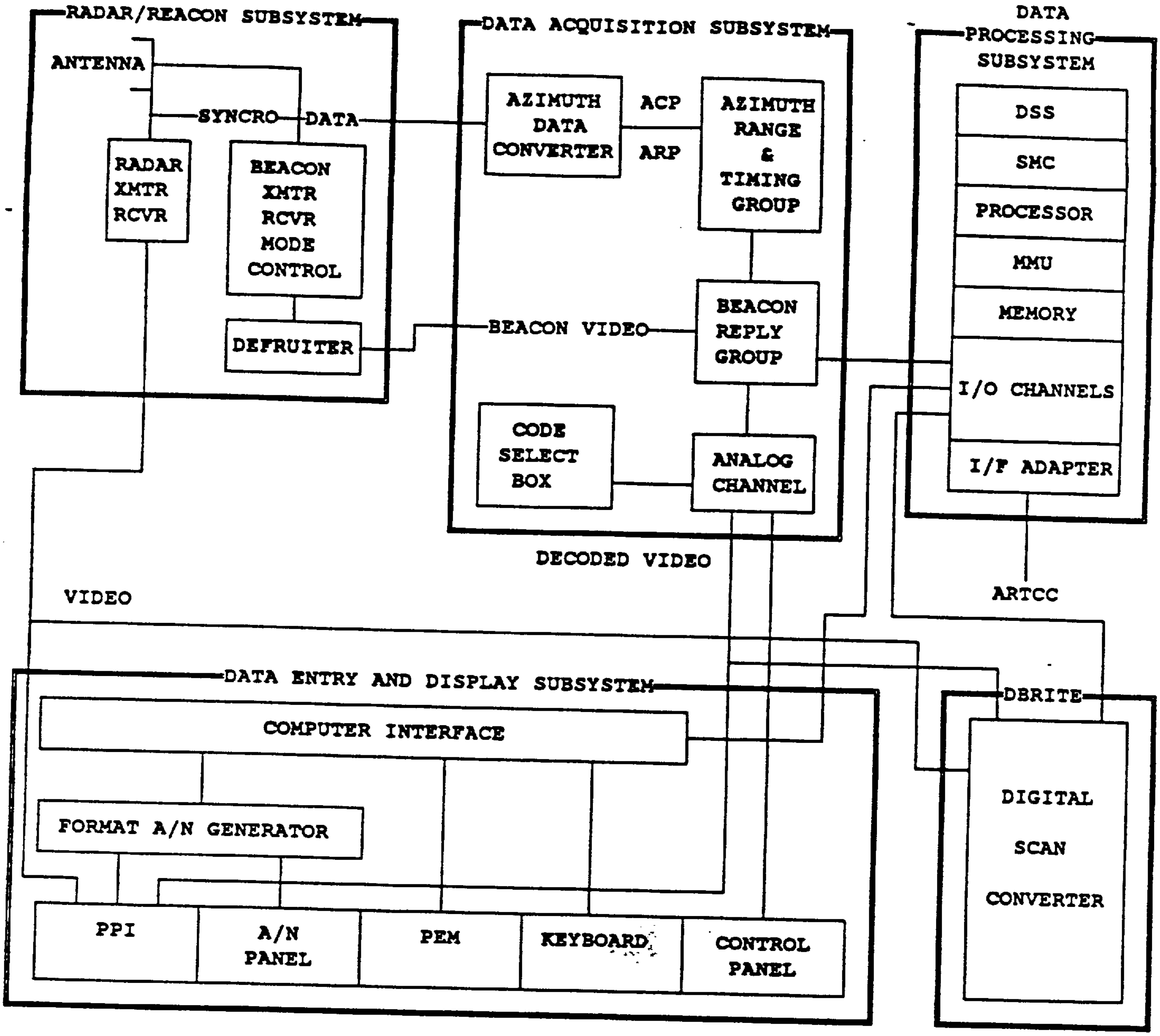


FIGURE 3.2-1 BASIC TRACON CONFIGURATION

2000229

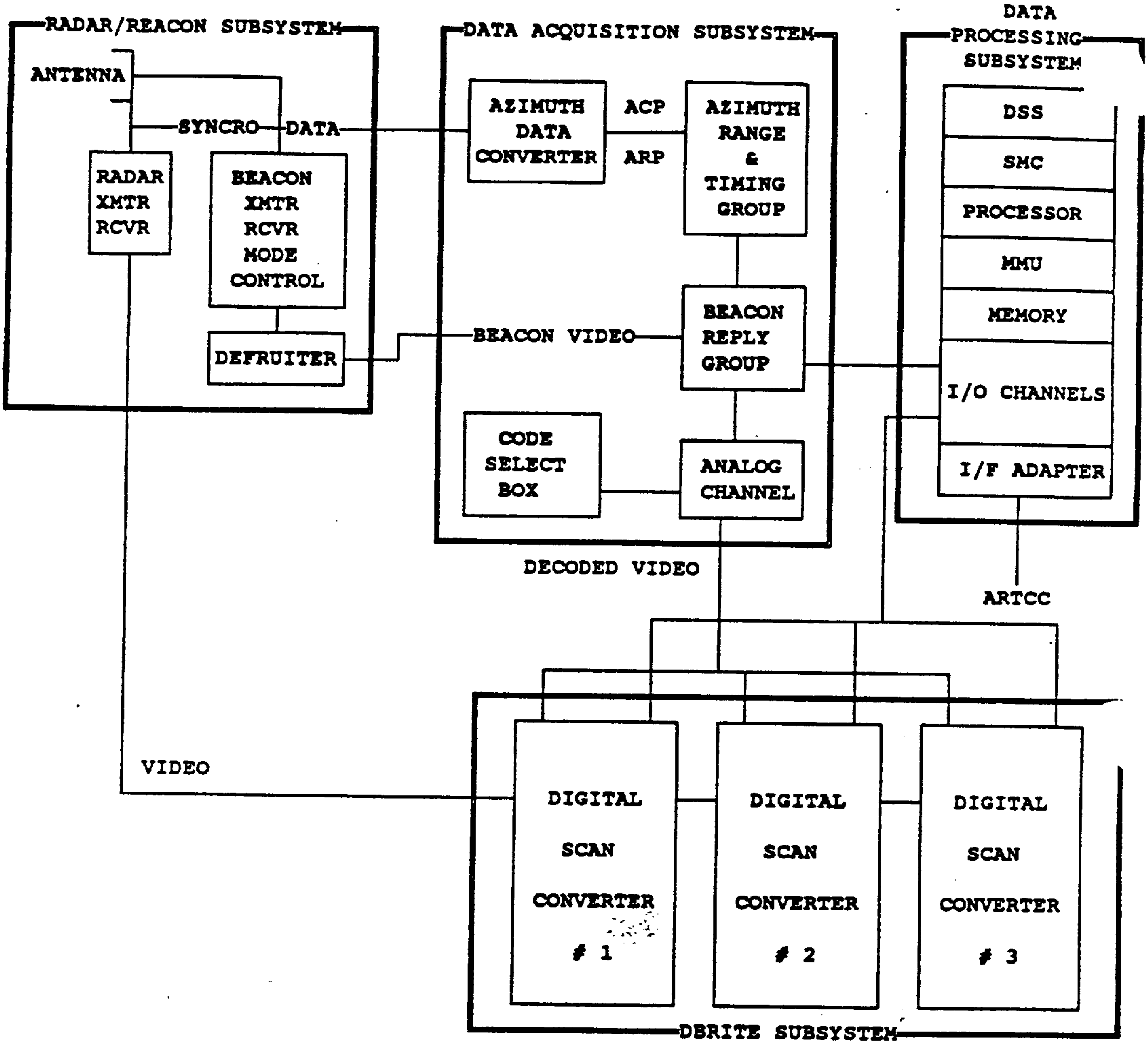


FIGURE 3.2-2 BASIC TRACAB CONFIGURATION

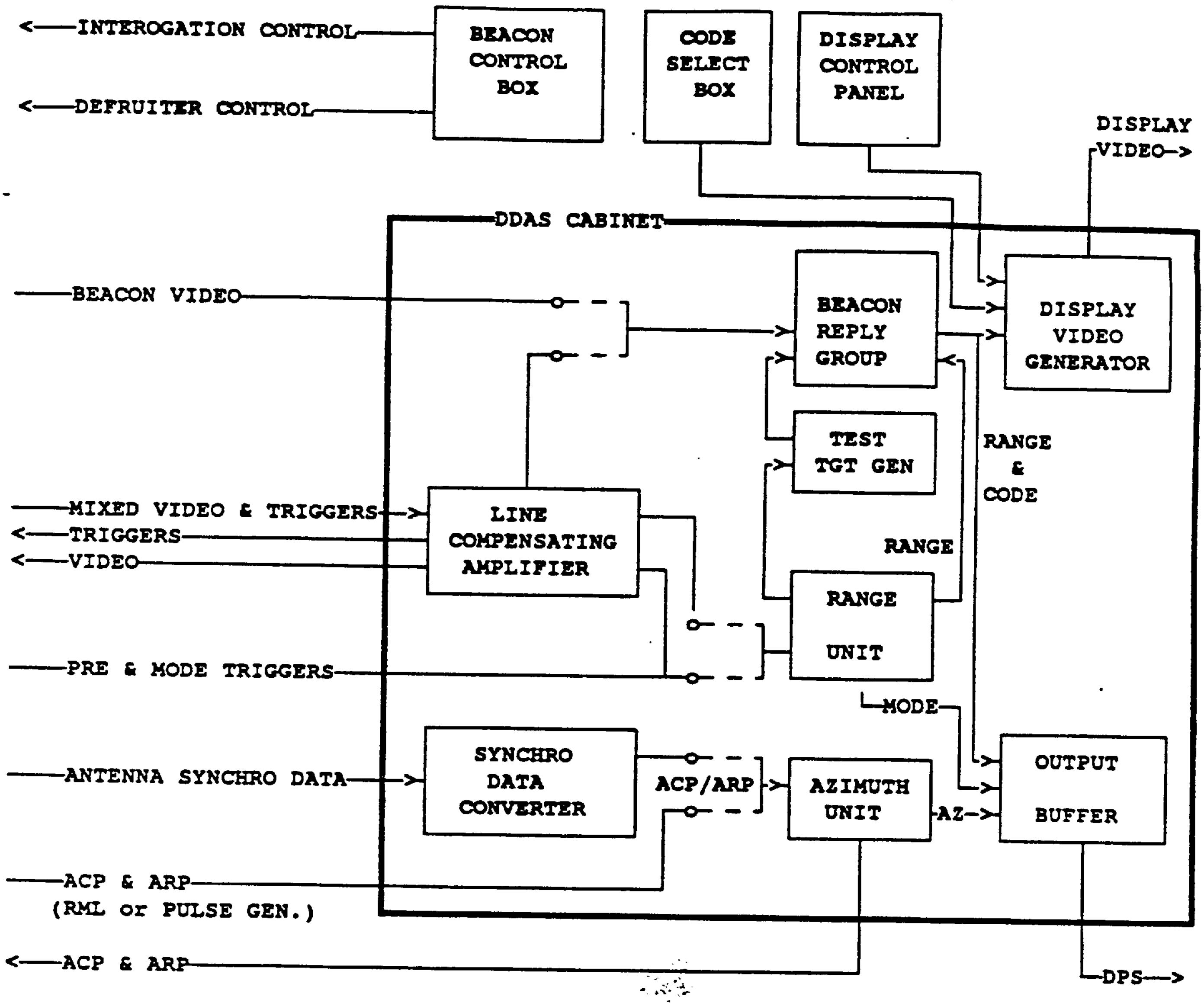


FIGURE 3.4-1 DECODING DAS BLOCK DIAGRAM

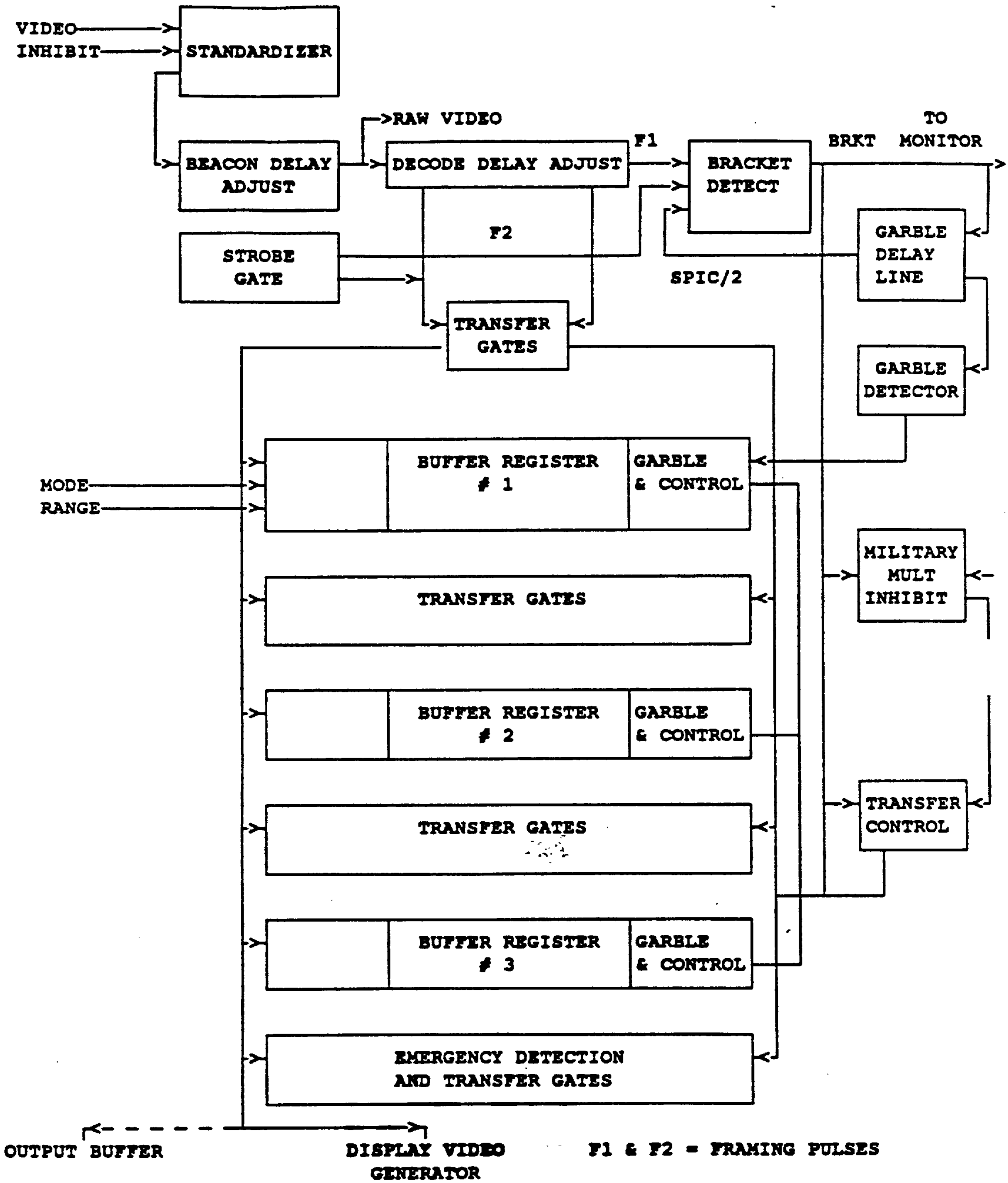


FIGURE 3.4-2 BEACON REPLY GROUP

2000232

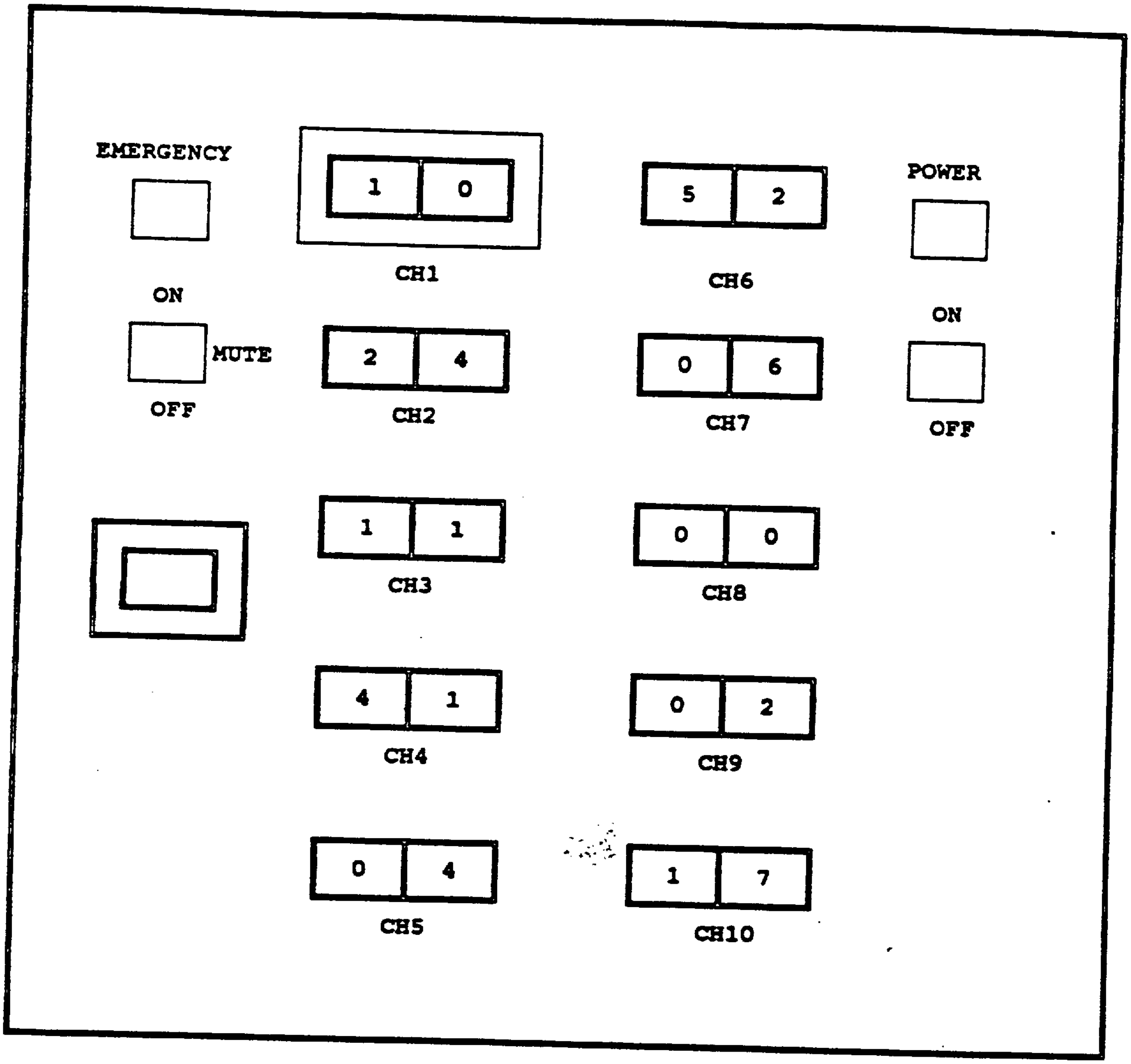


FIGURE 3.4-3 CODE SELECT BOX

2000233

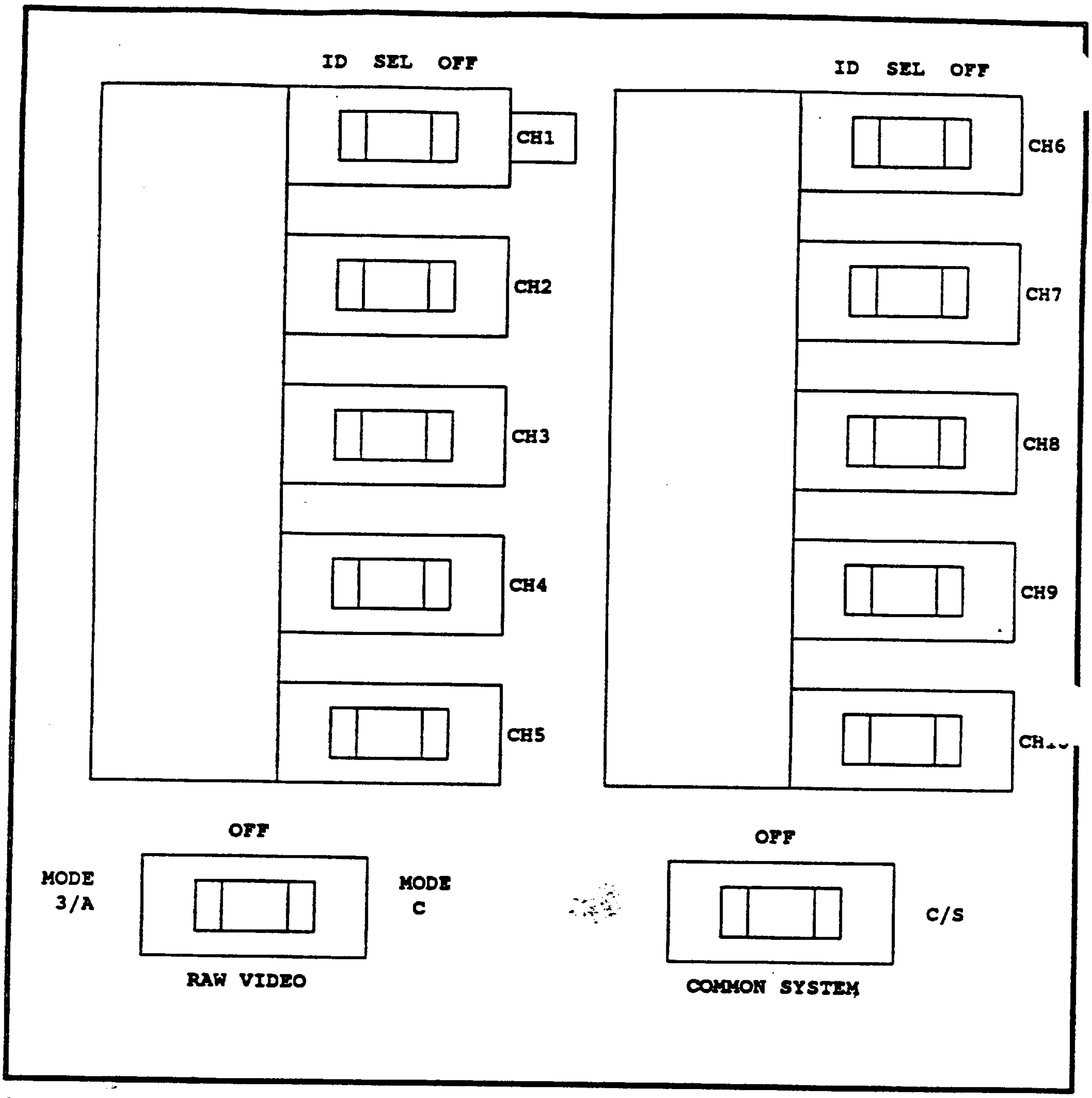
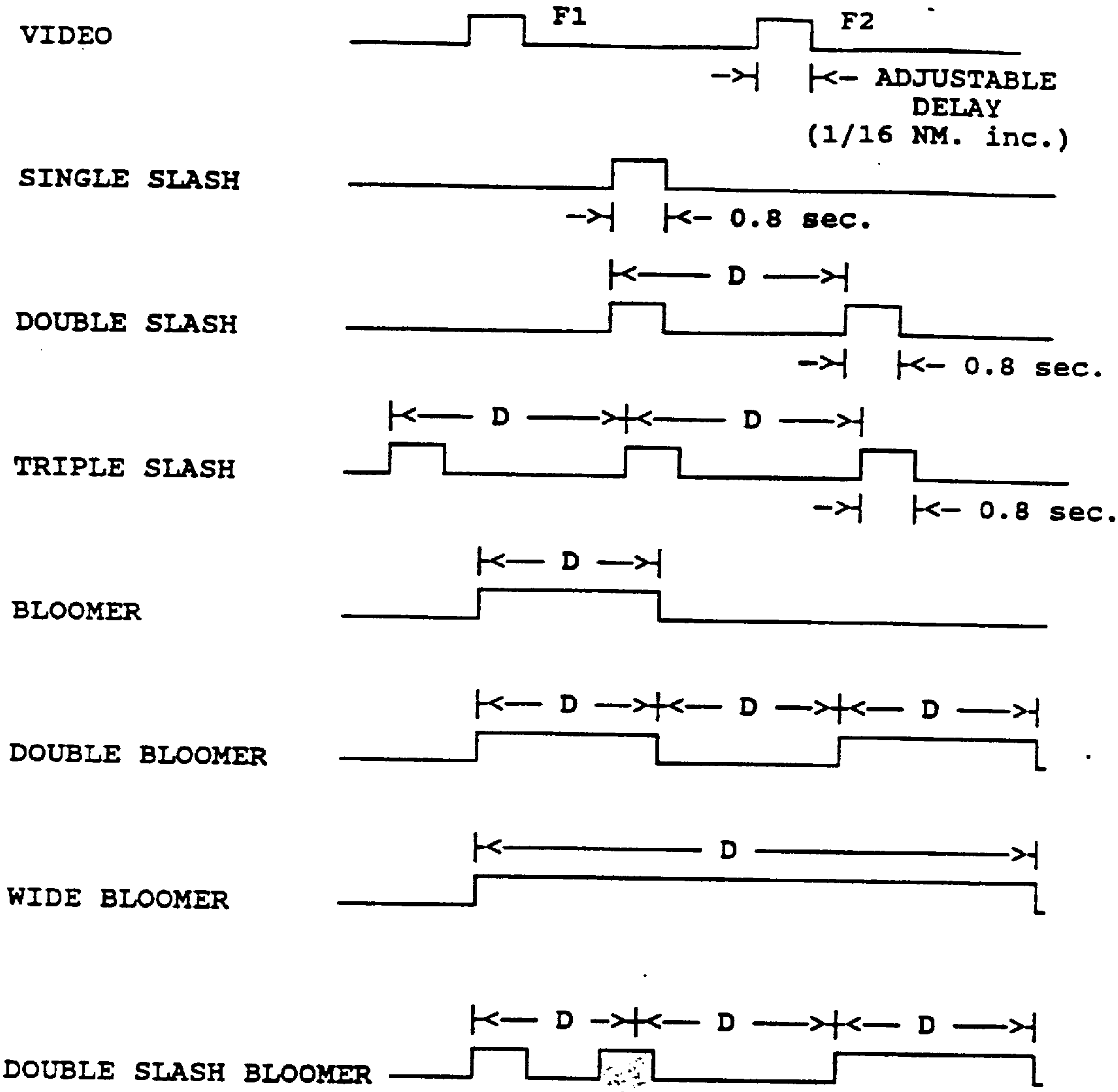


FIGURE 3.4-4 DISPLAY CONTROL PANEL



NOTE: "D" equals 2.48, 4.14, 5.80, 9.94, 11.60 or 13.25 usec dependent upon display range scale.

FIGURE 3.4-5 DISPLAY OUTPUT SYMBOLOGY

BIT #	SYNC MESSAGE	INITIAL MESSAGE (ACP'S)	ALARM MESSAGE	RANGE MESSAGE (NM)	CODE MESSAGE 3/A	CODE MESSAGE C
15	0	0	0	0	X	
14	0	0	0	0	SPI FLAG	
13	0	0	0	0	GARBLE FLAG	
12	0	0	0	0	MODE C	
11	0	2048	0	0	A4	D1
10	0	1024	0	0	A2	D2
9	0	512	0	32	A1	D4
8	0	256	ADC	16	B4	A1
7	0	128	0	8	B2	A2
6	0	64	Overload	4	B1	A4
5	0	32	Azimuth	2	C4	B1
4	0	16	Sensor	1	C2	B2
3	0	8	Range	1/2	C1	B4
2	0	4	0	1/4	D4	C1
1	Stagger Sync	2	0	1/8	D2	C2
0	Sector Pulse	1	0	1/16	D1	C4

TABLE 3.4.5-1 OUTPUT MESSAGE FORMATS

(ASSUMES 16-BIT DPS INTERFACE)

2000236

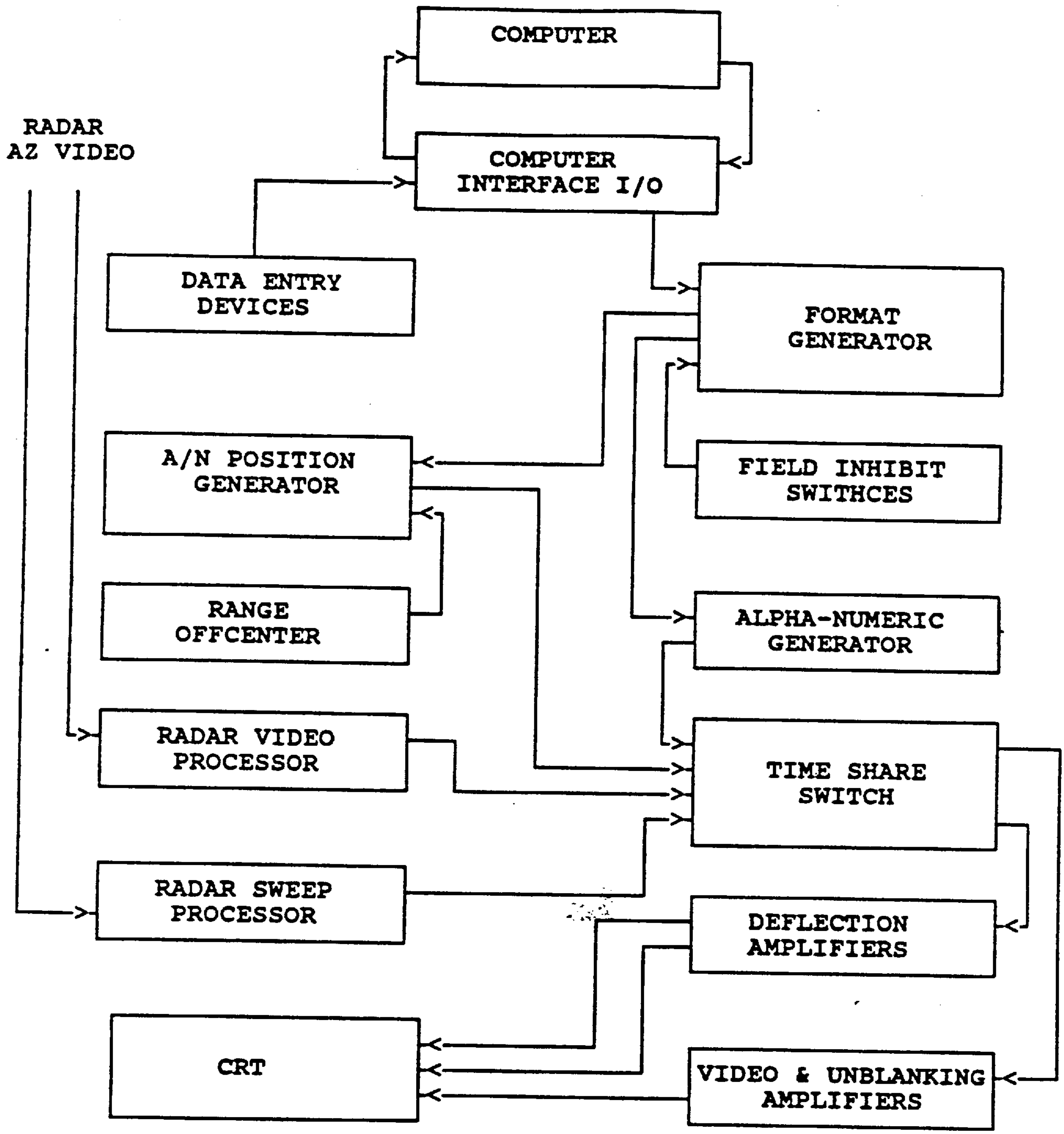


FIGURE 3.6-1 RADAR/ALPHANUMERIC AND DATA ENTRY BLOCK DIAGRAM

2000237

DATA	QUANTITY
Full Data Blocks	12
Limited Data Blocks	39
Single Symbols	25
Tabular Lines	9

Full Data Block	Consists of target symbol, leader, and tag of three lines - 7 data characters each for line 1 and 2, and 5 for line 3.
Limited Data Block	Consists of target symbol, leader, and tag of 2 lines - 4 characters in first line, 3 in second line.
Single Symbol	Consists of target symbology
Tabular Line	Position address and 10 characters.

FIGURE 3.6-2 DATA DISPLAY MODEL

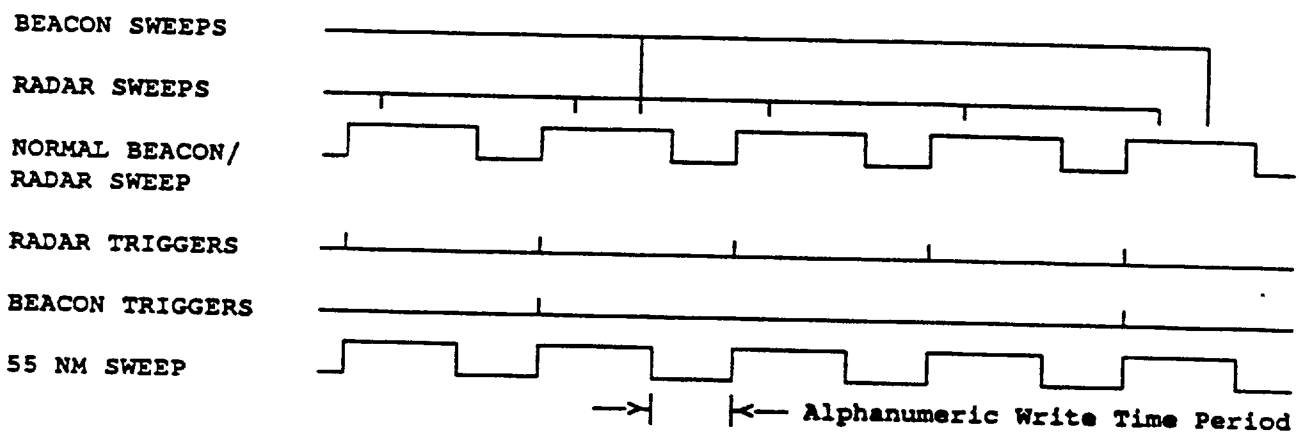


FIGURE 3.6-3 SYSTEM TIMING FOR 3 to 1 COUNT DOWN

RADAR BEACON SYSTEM

NON-STAGGERED MODE

Period No.	Radar Period (usec)	Radar PRF	Non-Staggered Countdown	Beacon Period (usec)	PRF Beacon
1	833	1200	3	2499	400
2	853	1173	3	2559	391
3	893	1120	3	2679	373
4	953	1050	3	2859	350
5	1053	950	3	3159	317
6	1400	713	2	2806	356

NOTES

1. One of the above periods will be selected for use in non-staggered mode.

2. The example above and for the staggered mode below represents the highest set of PRF's which will be encountered on the ASR-7. The lowest set of PRF's will be 25 percent lower than illustrated.

3. The beacon pretrigger will nominally be 100 usec prior to the modular trigger (zero, range) and the radar pretrigger will occur 60 usec prior to the modulator trigger.

STAGGERED MODE

Radar Period No.	4	2	5	1	6	3	4	2	5	1	6	3	4	2	5	1	
Radar Period (usec)	953	853	1053	833	1403	893	953	853	1053	833	1403	893	953	853	1053	833	140
Beacon Period (usec)	1806		1886		2296			2859			2236		1846		1906		31

NOTE 1: The average PRF for the beacon in the staggered mode is 445 and represents the highest average staggered beacon PRF.

FIGURE 3.6-4 CHARACTERISTICS OF ASR-7 PRF

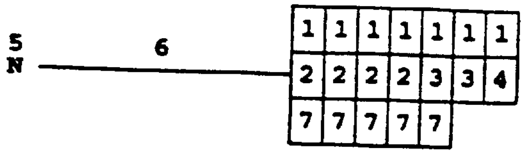
2000240

Refresh Minimum	30 Hz
Incident Light on CRT	0.3 fc
Brightness through CRT Filter	4 fl
Contrast Ratio	10:1
Maximum Spot Size on CRT	0.028 in
Spot Size Deviation on CRT	1.5:1

FIGURE 3.6-5 CRT PERFORMANCE FOR 22 inch CRT

CLEAR	BACK SPACE	SPACE							ENTER
MULTI FUNC	TRACK SUSP	TRACK START	TTG	INS		ARR CODE	DEP CODE	MSAW	CA
SYS	PRE	TAB	ALT LIMIT	DROP DATA	READ OUT	EN ROUTE	VFR CODE	*	SUP
A	B	C	D	E	F	G	┌ 1	^ 2	3 ┐
H	I	J	K	L	M	N	< 4	5	6 >
O	P	Q	R	S	T	U	└ 7	8 v	9 ┘
V	W	X	Y	Z	/	Δ	^	0	v

FIGURE 3.6-6 KEYBOARD LAYOUT



FIELD #	CHAR #	FIELD DESCRIPTION	FIELD DEFINITION	
1	1 - 7	AIRCRAFT IDENTITY		2 to 7 Alphanumeric Characters
2	1 - 3	ALTITUDE	Mode C or Assigned Altitude	3 Numeric Characters
			Unreasonable Altitude	XXX
	1 - 3	TRACK STATUS (Site) Site	Coast	CST
		Interfacility	No ARTS Track	NAT
			Ambiguous	AMB
2	4	ALTITUDE MODIFIER	Climbing	Up Arrow
			Descending	Down Arrow
			Assigned	A
	4	HANDOFF	Receiving Controllers Position ID	Alpha Character
2	1 - 4	REPORTED BEACON CODE	Reported Beacon Code	4 Octal Characters
3	1 & 2	GROUND SPEED	Track Ground Speed in Knots X 10	2 Numeric Characters
3	1 & 2	SPECIAL CONDITIONS		
		Special Codes	Emergency Code (7700)	EM
			Radio Failure (7600)	RF
			Hijack (7500)	HJ
		Interfacility	Center Departure Message Error	DM
			Center Handoff Initate/Accept Error	IF
			Center Handoff Data Error	OL
4	1	SPECIAL DESIGNATOR	Heavy	H
			VFR	V
			Enroute	E
			Adapted Discrete Code	Site Adapted
5		CONTROLLER POSITION SYMBOL	Aircraft Location & Controllers Identity	1 Alpha Character
6		LEADER	8 Directions	
7	1 - 5	ALERT	Low Altitude	LA
			Conflict	CA
			Both	LA/CA
			MSAW Inhibited	**/
			CA Inhibited	/ΔΔ
			Both Inhibited	**/ΔΔ

FIGURE 3.6-7 FULL DATA BLOCK FORMAT

2000243

DATA	QUANTITY
Full Data Blocks	24
Alert Data Blocks	2
Limited Data Blocks	78
Single Symbols	152
Tabular Lines	22
System Area	4
Arrival/Departure List	12
Alert List	2
Coast/Suspend List	2
Preview Area	2

Full Data Block	Consists of target symbol, leader, and tag of two lines - 7 data characters each for line 1 and 2.
Alert Data Block	Same as Full Data Block with an additional Line 3 with 5 Characters.
Limited Data Block	Consists of target symbol, leader, and tag of 2 lines - 4 characters in first line, 3 in second line.
Single Symbol	Consists of target symbology
Tabular Line	Position address and 15 characters.

FIGURE 3.7.5-1 DISPLAY VIDEO COMPRESSION DATA MODEL

DATA ACQUISITION SUBSYSTEM
(BEACON ONLY)

DATA PROCESSING SUBSYSTEM

-1 CPM
-1 MMU
-1 256K Word Memory
Interfaces
-1 Peripheral Equipment
-1 Display
-1 I/F adapter

DATA ENTRY AND DISPLAY SUBSYSTEM

-1 IFR Room Display
-1 Data Entry Device Set

FIGURE 3.8-1 RELIABILITY BLOCK DIAGRAM

APPENDIX A
CHARACTERISTICS
FOR
THE IFF MARK X (SIF)/AIR TRAFFIC CONTROL
RADAR BEACON SYSTEMS SIF/ATCRBS

10.1 GENERAL

10.1.1 Common System Component Characteristics

10.1.1.1 Under Public Law 85-726, the Federal Aviation Administration is charged with providing for the regulation and promotion of civil aviation in such manner as to best foster its development and safety, and to provide for the safe and efficient use of the airspace by both civil and military aircraft, and for other purposes. Explicitly, the Administrator shall develop, modify, test, and evaluate systems, procedures, facilities, and devices, as well as define the performance characteristics thereof, to meet the needs for safe and efficient navigation and traffic control of all civil and military aviation operating in a Common Civil/Military System of Air Navigation and Traffic Control.

10.1.1.2 A Common System Component Characteristic, the logical result of such development effort, specifies the performance required of a component (or subsystem) to meet the overall operational requirements of the Common System. It specifies the technical parameters, tolerances, and techniques to the extent required to insure proper operation and compatibility between elements of the Common System.

10.1.1.3 If optimum performance is to be obtained, these Common System Component Characteristics must be met by all civil and military users of the Air Traffic control Radar Beacon System under all expected operating conditions. It is recognized that certain existing equipment does not comply with all requirements of these characteristics. Since such equipment may degrade the quality of service to all users, it is expected that its usage will be phased out as soon as practicable.

10.1.2 System Characteristics and Guidance Material

10.1.2.1 The System Characteristics and Guidance Material provided herein are restricted to those systems elements which must be treated in a uniform manner by all concerned, both civil and military, if the IFF Mark X (SIF)/Air Traffic Control Radar Beacon System is to function satisfactorily.

In this connection,it is necessary to define closely many characteristics of the airborne component of the system (transponder). The system composed of the Mode 3 portion of the IFF Mark X (SIF) and Modes A and C of the Air Traffic Control Radar Beacon System shall be referred to herein as ATCRBS.

10.1.2.2 The following are the modes provided by the system, and their associated functions:

Mode 1 - For Military use.

Mode 2 - For Military use.

Mode 3/A - To initiate transponder response for identification and tracking.

Mode B - In some parts of the world, during a transition period, to initiate transponder response for identification and tracking.

Mode C - To initiate transponder responses for automatic pressure altitude transmission.

Mode D - For future expansion of the system to satisfy operational requirements that may be agreed by the International Civil Aviation Organization. No functional need for Mode D has been defined.

10.1.2.3 The Air Traffic Control (ATC) System will use Mode 3/A with 4096 identity codes and Mode C with pressure altitude transmission in 100-foot increments in providing separation service to both military and civil aircraft. There are no plans for use of Modes B and D in the United States.

10.1.2.4 The ATC System will provide vital support to military operation during periods of national emergency through the continued ATC use of Modes 3/A and C.

10.1.3 Operational Requirements

Revised operational requirements for the Common System ATCRBS were originally established by the President's Air Coordinating Committee in Paper AAC 59/20.1-1 dated February 24, 1953, which endorsed recommendations of the Joints Chiefs of Staff, Joint Communications-Electronics Committee as set forth in there memorandum CECM 58-53, Case 386-G, dated January 15, 1953. These recommendations were subsequently modified by classified correspondence to include a recognition of the 64-code capability of the ATCRBS and to provide for compatibility with the Military IFF Mark X System. Common System Component Characteristics for the ATCRBS were established by the president's Air Coordination Committee in Paper ACC 59/20.4, dated September 1957. Compatible system characteristics were approved by the International Civil Aviation Organization (ICAO), Sixth Communication Division, and published in the International Standards and Recommended Practices Aeronautical Telecommunications, Annex 10, Fifth Edition dated October 1958. Three-pulse side lobe suppression, automatic pressure-altitude transmission and other improvements were recommended by the ICAO Seventh Communications division and included in the report of the Seventh Session dated February 9, 1962. At the ICAO COM/OPS Meeting in 1966, the three-pulse method was designated as the sole means of side lobe suppression and 4096 identity codes were raised to standards. A standard of correspondence (paragraph 10.2.7.13.2.5) was established for automatic pressure-altitude transmission and functional description of the modes and their intended usage was defined.

10.1.3.1 Compatibility

The required compatibility of the Military Mark X (SIF) airborne transponders with the ICAO SSR (ATCRBS) has been established using the Military Mode 3 and Civil Mode A which are identical in characteristics. This mode of operation is referred to herein as Mode 3/A. The Memorandum of Understanding between the Department of Defense and the Federal Aviation on the Joint operational use of the Military IFF Mark X (SIF) System and the Common System Air Traffic Control Radar Beacon System, dated March 18, 1966, contains the agreement on the use of Modes 3/A and C.

10.1.3.2 System Coverage

The ATCRBS is intended to provide the air traffic controller with continuous, reliable, and accurate information concerning the plan-position (rho-theta), altitude, and identity of any or all equipped aircraft in the airspace under his control. With a properly sited Air Traffic Control Radar Beacon Interrogator-Receiver and other units having characteristics as stated herein, the ATCRBS will provide spatial line-of-sight coverage equal to or greater than the following limits:

a. Range .... 1 to 200* nautical miles

b. Elevation .... 1/2 to 45° above the horizontal plane

c. Altitude .... Limited only by service ceiling of aircraft

*Interrogators having limited range may be employed at many locations.

While it is necessary to establish specific standards for the airborne components of the system and to define the characteristics of the radiated signals from both the interrogator and transponder, the power and sensitivity requirements for the interrogator-receiver may be modified on the basis of the intended usage with due regard for the precautions outlined in the guidance material.

10.1.3.3 System Accuracy

The system accuracy is determined by the characteristics of the ATC beacon interrogator-receiver (including its antenna), transponder, altimeter and transducer, ground processing equipment, and the associated display. With equipment of present day design meeting the characteristics stated herein, ATCRBS is capable of providing data with in the following accuracies:

a. Range: ± 1000 feet

b. Azimuth: ± 1.0 degrees

c. Altitude Correspondence: Within ± 125 feet, on a 95 percent probability basis, with the pressure altitude information (referenced to the standard pressure setting of 29.92 inches of mercury) used on board the aircraft to adhere to the assigned flight profile.

10.1.3.4 Identification Coding

10.1.3.4.1 The ATCRBS is a valuable tool for identifying aircraft, as well as for providing radar target reinforcement.

The inherent capability of the system to provide radar identification of participating aircraft will be utilized to provide the controller with the specific radar beacon target identity of those aircraft equipped. The characteristics specified herein provide for 4096 discrete reply codes. In addition to the 4096 discrete reply codes, a Special Position Identification (SPI) pulse is available for transmission upon request of the control agency, on any mode except Mode C.

10.1.3.4.2 Two codes shall be reserved for transmission of distinct emergency and radio communications failure indications.

10.1.3.4.2.1 Code 7700 shall be used on Mode 3/A to provide recognition of aircraft in an emergency.

Note: Some existing military transponders transmit four trains of the code in use as an emergency reply. Others military transponders transmit the code in use followed by three trains of Code 0000 as the emergency reply. New military transponders will transmit Code 7700 followed by three trains of code 0000 as an emergency reply.

10.1.3.4.2.2 Code 7600 shall be used on Mode 3/A to provide recognition of an aircraft with radio communications failure.

10.1.3.5 Altitude Transmission

The system provides for automatic pressure-altitude data transmission in 100-foot increments from -1000 feet to 126,700 feet.

10.1.3.5.1 This pressure altitude data transmission capability will be used to:

a. Reduce the volume of communications between controllers and pilots by obviating the need for oral altitude reports.

b. Improve utilization of airspace in connection with the provision of ATC services to climbing and descending aircraft.

c. Enable the controller, when desirable, to assure himself that vertical separation between two aircraft is being maintained.

d. Provide ATC an improved means of determining when greater vertical separation is required due to turbulence.

e. Improve the integrity of the Air Traffic control Radar Beacon System (ATCRBS) for ATC purposes by automatically displaying to the controller the targets and altitudes or flight levels of aircraft in or near the airspace under his jurisdiction which are not otherwise selected for display.

f. Reduce the number of advisories and traffic avoidance vectors required in the provision of radar traffic information and vectoring service.

g. Improve ATC efficiency in serving high performance aircraft during cruise-climb profiles.

h. Enable automatic prediction of projected flight conflicts in elevation using electronic data processing systems.

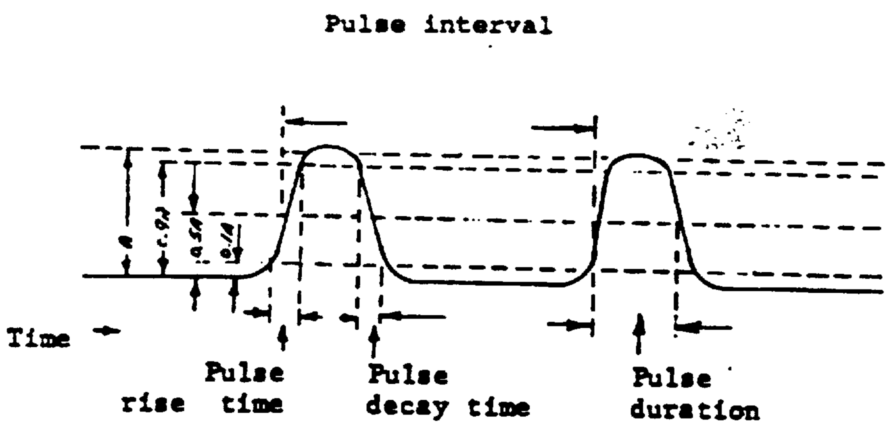
10.1.4 ATCRBS System Description

The System consists of airborne transponders, group interrogator-receiver, processing equipment, and an antenna system. The antenna may or may not be associated with, or slaved to, a primary surveillance radar. In operation, an interrogation pulse-group transmitted from the interrogator-transmitter unit, via an antenna assembly, triggers each airborne transponder located in the direction of the main beam, causing a multiple-pulse reply group to be transmitted from each transponder. These replies are received by the ground receiver and, after processing, are displayed to the controller. Measurement of the round-trip transmit time determines the range(rho) to the replying aircraft while the mean direction of the main beam of the interrogator antenna, during the reply, determine the azimuth (theta). The arrangement of the multiple-pulse reply provides individualized pressure altitude and identity information pertaining to the responding aircraft.

The ATCRBS is the preferred means of obtaining aircraft three dimensional position and identification data in the National Airspace System.

10.2 SYSTEM CHARACTERISTICS

PULSE SHAPE AND SPACING DEFINITIONS



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Definitions

Pulse amplitude A.	The peak voltage amplitude of the pulse envelope.
Pulse duration.	The time interval between 0.5A points on leading and trailing edges of the pulse envelope.
Pulse interval.	The time interval between the 0.5A point on the leading edge of the first pulse and the 0.5A point on the leading edge of the second pulse.
Pulse rise time.	The rise time as measured between 0.1A and 0.9A on the leading edge of the pulse envelope.
Pulse decay time.	The decay time as measured between 0.9A and 0.1A on the trailing edge of the pulse envelope.

10.2.1 <u>Interrogation and Control (Interrogation Side Lobe Suppression) Radio Frequencies (ground-to-air)</u>

10.2.1.1 Center frequency of the interrogation and control transmissions shall be 1030 MHz.

10.2.1.1.1 The frequency tolerance shall be $\pm$ 0.2 MHz.

10.2.1.2 Center frequencies of the control transmission and each of the interrogation pulse transmissions shall not differ from each other by more than 0.2 MHz.

10.2.2 <u>Reply Radio Frequency (air-to-ground)</u>

10.2.2.1 Center frequency of the reply transmission shall be 1090 MHz.

10.2.2.1.1 The frequency tolerance shall be $\pm$ 3 MHz.

10.2.3 <u>Polarization</u>

10.2.3.1 Polarization of the interrogation, control, and reply transmissions shall be predominantly vertical.

10.2.4 <u>Interrogation Modes (signals-in space)</u>

10.2.4.1 The interrogation shall consist of two transmitted pulses designated P_1 and P_3. A control pulse P_2 shall be transmitted following the first interrogation pulse P_1.

10.2.4.2 The interrogation modes shall be as defined in 10.2.4.3.

10.2.4.3 The interval, between P_1 and P_3, shall determine the mode of interrogation and shall be as follows:

Mode 1	3 $\pm$ 0.1 Microseconds
Mode 2	5 $\pm$ 0.2 Microseconds

Mode 3/A	8 $\pm$ 0.2 Microseconds
Mode B	17 $\pm$ 0.2 Microseconds
Mode C	21 $\pm$ 0.2 Microseconds
Mode D	25 $\pm$ 0.2 Microseconds

10.2.4.4 The interval, between P_1 and P_2 shall be 2.0 $\pm$ 0.15 microseconds.

10.2.4.5 The duration of pulses P_1, P_2, and P_3 shall be 0.8 $\pm$ 0.1 microseconds.

10.2.4.6 The rise time of pulses P_1, P_2, and P_3 shall be between 0.05 and 0.1 microsecond.

NOTE: The intent of the lower limit of decay time (0.05 microsecond) is to reduce sideband radiation. Equipment will meet this requirement if the sideband radiation is no greater than that which theoretically would be produced by a trapezoidal wave having the stated rise time.

10.2.4.7 The decay time of pulses P_1, P_2, and P_3 shall be between 0.05 and 0.2 microsecond.

NOTE: The intent of the lower limit of decay time (0.05 microsecond) is to reduce sideband radiation. Equipment will meet this requirement if the sideband radiation is no greater than that which theoretically would be produced by a trapezoidal wave having the stated rise time.

10.2.5 Interrogation and Side Lobe Suppression Transmission Characteristics (signals-in-space)

10.2.5.1 The system relies on pulse amplitude comparison between pulses P_1 and P_2, in the transponder to prevent response to side lobe interrogation. The radiated amplitude of P_2 at the antenna of the transponder shall be (1) equal to or greater than the radiated amplitude of P_1 from the greatest side lobe transmission of the antenna radiating P_1, and (2) at a level lower than 9 dB below the radiated amplitude of P_1 within the desired arc of interrogation.

10.2.5.2 Within the desired arc of the directional interrogation (main lobe) the radiated amplitude of P_3 shall not be more than 1 dB below the radiated amplitude of P_1.

10.2.6 Reply Transmission Characteristics (signals-in-space)

10.2.6.1 Framing Pulses

The reply function shall employ a signal comprising two framing pulses spaced 20.3 microseconds, as the most elementary code.

10.2.6.2 Information Pulses

Information pulses shall be spaced in increments of 1.45 microseconds from the first framing pulse. The designation and position of these information pulses shall be as follows:

Pulse	Position (Microseconds)
C_1	1.45
A_1	2.90
C_2	4.35
A_2	5.80
C_4	7.25
A_4	8.70
X	10.15
B_1	11.60
D_1	13.05
B_2	14.50
D_2	15.95
B_4	17.40
D_4	18.85

NOTE: The Standard relating to the use of these pulses is given in 10.1.3.4. However, the position of the "X" pulse is specified only as a technical standard to safeguard possible future use. Further guidance on this matter is given in the guidance material in paragraph 10.3.3.6.

10.2.6.3 Special Position Identification (SPI) Pulse

In addition to the information pulses provided, a Special Position Identification Pulse, which may be transmitted with the information pulses, shall occur at a pulse interval of 4.35 microseconds following the last framing pulse.

10.2.6.4 Reply Pulse Shape

All reply pluses shall have a pulse duration of 0.45 ± 0.10 microsecond, a pulse rise time between 0.05 and 0.1 microsecond. The pulse amplitude variation of one pulse with respect to any other pulse in a reply train shall not exceed 1 dB.

NOTE: The intent of the lower limit of rise and decay time (0.05 microsecond) is to reduce sideband radiation. Equipment will meet this requirement if the sideband radiation is no greater than that which theoretically would be produced by a trapezoidal wave having the stated rise and decay times.

10.2.6.5 Reply Pulse Interval Tolerances

The pulse interval tolerance for each pulse (including the last framing pulse) with respect to the first framing pulse of the reply group shall be ± 0.10 microsecond. The pulse interval tolerance of the Special Position Identification Pulse with respect to the last framing pulse of the reply group shall be ± 0.10 microsecond. The pulse interval tolerance of any pulse in the reply group with respect to any other pulse (except the first framing pulse) shall not exceed ± 0.15 microsecond.

10.2.6.6 Code Nomenclature

The code designations shall consists of four digits, each of which lies between 0 and 7, inclusive, and is determined by the sum of the pulse subscripts given in 10.2.2.6, employed as follows:

Digit	Pulse Group
First (most significant)	A
Second	B
Third	C
Fourth	D

10.2.6.6.1 Examples:

a. Code 3600 would consist of information pulses A_1, A_2, B_2, and B_4.

b. Code 2057 would consist of A_2, C_1, C_4, D_1, D_2, and D_4.

c. Code 0301 would consist of B_1, B_2, and D_1.

10.2.7 Technical Characteristics of the Airborne Transponder

10.2.7.1 Reply

When selected to reply to a particular interrogation mode, the transponder shall reply (not less than 90% efficiency) when all of the following conditions have been met:

10.2.7.1.1 The received amplitude of P_3 is in excess of a level 1 dB below the receive amplitude of P_1 but no greater than 3 dB above the receive amplitude of P_1.

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10.2.7.1.2 Either the received amplitude of P_1 is in excess of a level 9 dB above the receive amplitude of P_2, or no pulse is received at the position 2 ± 0.7 microseconds following P_1.

10.2.7.1.3 The received amplitude of a proper interrogation is more than 10 dB above the received amplitude of random pulses where the latter are not recognized by the transponder as P_1, P_2, or P_3.

10.2.7.2 No Reply

The transponder shall not reply to more than 10% of the interrogations under the following conditions:

10..2.7.2.1 To interrogations when the interval between pulses P_1 and P_3 differs from that specified in 10.2.4.3 for the mode selected in the transponder by more than ± 1.0 microsecond.

10.2.7.2.2 Upon receipt of any single pulse which has no amplitude variations approximating a normal interrogation condition.

10.2.7.3 Dead Time

After reception of a proper interrogation, the transponder shall not reply to any other interrogation at least for the duration of the reply pulse train. This dead time shall end no later than 125 microseconds after the transmission of the last reply pulse of the group.

10.2.7.4 Suppression

Upon receipt of an interrogation, complying with 10.2.4 in respect to the mode selected manually or automatically, the transponder shall be suppressed (not less than 99% efficiency) when the received amplitude of P_2 is equal to or in excess of the received amplitude of P_1, and spaced 2 ± 0.15 microseconds.

NOTE: It is not the intent of this paragraph to require the detection of P_3 as a prerequisite for initiation of suppression action.

10.2.7.4.1 The transponder suppression shall be for a period of 35 ± 10 microseconds.

10.2.7.4.2 The suppression shall be capable of being reinitiated for the full duration with in two microseconds after the end of any suppression period.

10.2.7.5 Receiver Sensitivity and Dynamic Range

10.2.7.5.1 The minimum triggering level (MTL) of the transponder shall be such that replies are generated to 90% of the interrogation signals when:

10.2.7.5.1.1 the two pulses P_1, and P_3 constituting an interrogation are of equal amplitude and P_2 is not detected; and,

10.2.7.5.1.2 The amplitude of these signals received at the antenna and of the transmission line of the transponder is nominally 71 dB below 1 milliwatt with limits between 69 and 77 dB below 1 milliwatt.

NOTE: For this MTL requirement, a nominal 3 dB transmission line loss and an antenna performance equivalent to that of a simple quarter wave antenna are assumed. In the event these assumed conditions do not apply, the MTL of the installed transponder system must be comparable to that of the assumed system.

10.2.7.5.2 The variation of the minimum triggering level between modes shall not exceed 1 dB for nominal pulse spacings and pulse widths.

10.2.7.5.3 The reply and suppression characteristics shall apply over a received signal amplitude range between 3 dB above minimum triggering level and 50 dB above minimum triggering level.

10.2.7.6 Signals of received amplitude between minimum triggering level and 6 dB above this level, and of a duration less than 0.3 microsecond at the antenna, shall not cause the transponder to initiate more than 10% reply or suppression action. With the exception of single pulses with amplitude variations approximating an interrogation, any single pulse of a duration more than 1.5 microseconds shall not cause the transponder to initiate reply or suppression action over the signal amplitude range of minimum triggering level (MTL) to 50 dB above that level.

10.2.7.7 Echo Suppression and Recovery

The transponder shall contain an echo suppression facility designed to permit normal operation in the presence of echoes of signals in space. The provision of this facility shall be compatible with the requirements for suppression of side lobes given in 10.2.7.4.

10.2.7.7.1 Desensitization

Upon receipt of any pulse more than 0.7 microseconds in duration, the receiver shall be desensitized by an amount that is within at least 9 dB of the amplitude of the desensitizing pulse, but shall at no time exceed the amplitude of the desensitizing pulse, with the exception of possible overshoot during the first microsecond following the desensitizing pulse. Single pulses of duration less than 0.7 microsecond are not required to cause the specified desensitization, but may not cause desensitization of duration greater than permitted by 10.2.7.7.1 and 10.2.7.7.2.

10.2.7.7.2 Recovery

Following desensitization, the receiver shall recover sensitivity (within 3 dB of minimum triggering level) within 15 microseconds after reception of a desensitizing pulse having a signal strength up to 50 dB above minimum triggering level. Recovery shall be nominally linear at an average rate not exceeding 3.5 dB per microsecond.

NOTE: Transponders that respond to military modes will recover within 15 microseconds, but may employ methods other than nominally linear recovery.

10.2.7.8 Random Triggering Rate

Installation in the aircraft shall be made in such manner that, with all possible interfering equipments installed in the same aircraft operating in their normal manner on operational channels of maximum interference, but with the absence of bona fide interrogations, the random triggering rate (squitter) of the transponder shall not exceed thirty replies per second as integrated over an interval equivalent to at least 300 random triggers, or 30 seconds, whichever is less.

10.2.7.9 Interference Suppression Pulses

If the equipment is designed to accept and respond to suppression pulses from other electronic equipment in the aircraft (to disable it while the other equipment is transmitting), the equipment must regain normal sensitivity, within 3 dB, not later than 15 microseconds after the end of the applied suppression pulse.

10.2.7.10 Reply Rate

10.2.7.10.1 For equipment intended for installation in aircraft which operate at altitudes above 15,000 feet, the transponder shall be capable of at least 1,000 replies per second for a 15-pulse coded reply.

10.2.7.10.2 For equipment intended for installation in aircraft which operate at altitudes not exceeding 15,000 feet, the transponder shall be capable of at least 1,000 replies per second for a 15-pulse coded reply.

10.2.7.10.3 A sensitivity reduction type reply rate limit control shall be incorporated in the transponder. The range of this control shall permit adjustment, as a minimum, to any value between 500 and 2,000 replies per second, or to the maximum reply rate capability, without regard to the number of pulses in each reply. Sensitivity reduction in excess of 3 dB shall not take effect until 90% of the selected value is exceeded. Sensitivity reduction shall be at least 30 dB for rates in excess of 150% of the selected value.

10.2.7.10.3.1 Recommendation

The reply rate limit control should be set at 1200 replies per second, or the maximum value below 1200 replies per second of which the transponder is capable (see 10.2.7.10.2).

10.2.7.11 Reply Delay and Jitter

The time delay between the arrival at the transponder of the leading edge of P_3, and the transmission of the leading edge of the first pulse of the reply shall be 3 $\pm$ 0.5 microseconds. The total jitter of the reply pulse code group, with respect to P_3, shall not exceed 0.1 microsecond for receiver input levels between 3 and 50 dB above minimum triggering level. Delay variations between modes on which the transponder is capable of replying shall not exceed 0.2 microsecond.

10.2.7.12 <u>Transponder Power Output</u>

10.2.7.12.1 For equipment intended for installation in aircraft which operate at altitudes above 15,000 feet, the peak pulse power available at the antenna end of the transmission line of the transponder shall be at least 21 dB and not more than 27 dB above 1 watt.

10.2.7.12.2 For equipment intended for installation in aircraft which operate at altitudes not exceeding 15,000 feet, the peak pulse power available at the antenna end of the transmission line of the transponder shall be at least 18.5 dB and not more than 27 dB above 1 watt.

<u>NOTE:</u> For the power output requirement of 10.2.7.12.1 and 10.2.7.12.2 a nominal 3 dB transmission line loss and an antenna performance equivalent to that of a simple quarter-wave antenna are assumed. In the event these assumed conditions do not apply, the peak pulse power of the installed transponder system must be comparable to that of the assumed system.

10.2.7.13 <u>Reply Codes</u>

10.2.7.13.1 <u>Identification</u>

The 4096 codes available in the Standard at 10.2.6.2 shall be manually selectable for reply to interrogations on Mode 3/A.

10.2.7.13.2 <u>Pressure-Altitude Transmissions</u>

10.2.7.13.2.1 Independently of the other modes and codes manually selected, the transponder shall automatically reply to Mode C interrogations.

<u>NOTE:</u> Military transponders may include provisions to disable Mode C replies.

10.2.7.13.2.2 The reply to Mode C interrogations shall consist of the two framing pulses specified in 10.2.6.1 together with information pulses specified in 10.2.6.2.

10.2.7.12.2.3 At as early a date as practicable, transponders shall be provided with means to remove the information pulses, but to retain the framing pulses when the provision of 10.2.7.13.2.5 is not complied with, in reply to Mode C interrogation.

<u>NOTE:</u> The information pulses should be capable of being removed either in response to a failure detection system or manually at the request of the controlling agency.

10.2.7.13.2.4 The information pulses shall be automatically selected by an analog-to-digital converter connected to a pressure-altitude data source in the aircraft referenced to the standard pressure setting of 29.92 inches of mercury.

10.2.7.13.2.5 Pressure altitude shall be reported in 100-foot increments by selection of pulses as shown in Figure 1.

NOTE: Some transponder. in service transmit the Special .osition Identification (SPI) pulse in addition to the :. pulse.

10.2.7.13.2.6 The digitizer code selected sha.' correspond to within ± 125 feet, on a 95 percent probability basis, with the pressure altitude information (referenced to the standard pressure setting of 29.92 inches of mercury) used on board the aircraft to adhere to the assigned flight profile.

NOTE: Guidance material relating to pressure altitude transmission is contained in 10.3.3.4 and 10.3.3.5.

10.2.7.14 Transmission Time of Special Position Identification (SPI) Pulse

When manually selected, the SPI pulse shall be transmitted for a period of between 15 and 30 seconds and must be capable of being reinitiated at any time.

10.2.7.15 Transponder Receiver Bandwidth

The skirt bandwidth should be such that the sensitivity of the transponder is at least 60 dB down at frequencies outside the band 1030 ± 25 MHz.

10.2.7.16 Transponder Self-Test and Monitor

10.2.7.16.1 Self-test and monitor devices that radiate test interrogation signals, or prevent transponder reply to proper interrogation during the test period, shall be limited to intermittent use which is no longer than required to determine the transponder status.

10.2.7.16.2 The test interrogation rate shall not exceed 450 per second and the test interrogation signal level at the antenna end of the transmission line shall not exceed a level of -70 dBm.

10.2.7.17 Antenna

10.2.7.17.1 The transponder antenna system, when installed on an aircraft, shall have a radiation pattern which is essentially omni-directional in the horizontal plane.

10.2.7.17.2 Recommendation

The vertical beamwidth (half power points) should be at least 30 degrees above and below the horizontal plane.

NOTE: Guidance material relating to airborne equipment antenna(s) is contained in 10.3.3.2.

10.2.8 Technical Characteristics of the Interrogator-Receiver

10.2.8.1 Interrogation Repetition Frequency

The maximum interrogation repetition frequency shall be 450 interrogations per second.

NOTE: This value is the sum total of the interrogation rate of all modes in use.

10.2.8.1.1 Recommendation

To minimize unnecessary transponder triggering and the resulting high density of mutual interference, all interrogators should use the lowest practicable interrogation repetition frequency that is consistent with the display characteristics, interrogator antenna beamwidth, and antenna rotation speed employed.

10.2.8.2 Power Output

10.2.8.2.1 The effective radiated peak power of interrogation pulses (P_1 and P_3) shall not exceed 52.5 dB above one watt.

NOTE: The effective radiated peak power includes the antenna gain and the transmission line losses. The effective radiated peak power of interrogation should be the minimum required to provide the system coverage. The system coverage stated in 10.1.3.2 can be met by an interrogator having a nominal 1000 watts power (peak pulse), a transmission line loss of 3 dB, and an antenna gain of 21 dB.

10.2.8.2.2 Interrogators with range coverage requirements of less than 200 miles will be employed at many locations. The effective radiated peak power of interrogation at these sites shall be reduced to the minimum required level which is practical to achieve.

10.2.8.3 Receiver Sensitivity

10.2.8.3.1 The maximum receiver sensitivity shall be not less than 85 dB below one milliwatt, to produce a tangential signal output, for a 200-mile facility.

NOTE: For this receiver sensitivity requirement, a nominal 3 dB transmission line loss and an antenna gain of 21 dB are assumed.

10.2.8.3.2 Interrogators with range coverage requirements of less than 200 miles will be employed at many locations. The maximum receiver sensitivity at these sites many be reduced to the minimum required level.

10.2.8.4 Sensitivity Time Control (STC)

The receiver sensitivity shall be reduced at short range to minimize reply path reflections and pulse stretching. At 15.36 microseconds after the leading edge of pulse P_3, (1 nautical mile plus transponder delay) the gain shall be reduced to an adjustable value between 10 and 50 dB below maximum sensitivity. The recovery rate shall be adjusted to suit local conditions.

10.2.8.4.1 Recommendation

Following the initial reduction of sensitivity at 15.36 us after the leading edge of pulse P_3 (1 nautical mile plus transponder delay), a recovery rate of 6 dB for each doubling of range is satisfactory for most applications.

10.2.8.5 Receiver Bandwidth and Video Response

The bandwidth of the receiver shall be centered on 1090 MHz and shall be adequate to reproduce the transponder pulse train described in paragraph 10.2.6 and to accommodate the transponder transmitter frequency tolerance and interrogator receiver local oscillator drift. The bandwidth shall not be more than 24 MHz at 40 dB below maximum sensitivity. The video response shall be capable of reproducing the pulse trains described in paragraph 10.2.6 without appreciable pulse stretching or distortion over a dynamic range from receiver threshold to a level 24 dB above threshold, at any range with STC provisions operative.

10.2.8.5.1 Image Response

The image response shall be at least 60 dB below maximum sensitivity.

10.2.8.6 Azimuth Accuracy

The electrical alignment of the main lobe of the directional antenna radiation pattern, with respect to the associated display shall be such as to permit received replies to be displayed within 1 degree of true orientation.

10.2.9 Interrogator Radiated Field Pattern

Recommendation

The beamwidth of the directional interrogator antenna should not be wider than is operationally required. The side and back-lobe radiation of the directional antenna should be at least 24 dB below the peak of the main-lobe radiation.

10.2.10 Interrogator Monitor

10.2.10.1 The range and azimuth accuracy of the ground interrogator shall be monitored continuously.

NOTE: Interrogators that are associated with and operated in conjunction with primary radar may use the primary radar as the monitoring device; alternatively an electronic range and azimuth accuracy monitor would be required.

10.2.10.2 Recommendation

In addition to range and azimuth monitoring, provision should be made to monitor continuously the other critical parameters of the ground interrogator for any degradation of performance exceeding the allowable system tolerances and to provide an indication of any such occurrence.

NOTE: Guidance on those system parameters for which continuous or periodic monitoring provisions are of particular importance is to be found in paragraph 10.3.2.7.

10.2.11 Spurious Emissions and Spurious Responses

10.2.11.1 Spurious Radiation

Spurious radiation shall not exceed 76 dB below 1 watt for the interrogator and 70 dB below 1 watt for the transponder.

10.2.11.2 Spurious Responses

The response of both airborne and ground equipment to signals not within the receiver bandpass shall be at least 60 dB below maximum sensitivity.

10.3 GUIDANCE MATERIAL RELATED TO THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM CHARACTERISTICS

10.3.1 Factors Affecting Optimum Utilization of the System

A number of specific precautions may be taken in order to obtain maximum utilization of the ATCRBS system, such as:

10.3.1.1 Coordination of the number and type of interrogators installed in any particular area, and cooperative use of interrogators, where possible for several related functions.

10.3.1.2 Use for each interrogator of the lowest power output which is required to perform its function.

10.3.1.3 Use for each interrogator of the lowest power output which is required for it to provide satisfactory performance.

10.3.1.4 Use of particular interrogators only during the periods necessary for them to perform their function.

10.3.1.5 Limitation of antenna beamwidth to the minimum required and use of low side-lobe antennas.

10.3.1.6 Coordination of the interrogation repetition frequency used to minimize interference.

10.3.2 Application consideration of the ATCRBS System

10.3.2.1 Siting

Care should be taken in siting the ground interrogator to ensure that the number of ground installations is kept to a minimum consistent with the operational requirement for ATCRBS information. It should be emphasized that the effects obtained by reflection of the main lobe are more serious than those associated with primary radar. It is therefore necessary to ensure that no large vertical reflecting surfaces are within a reasonable distance of the ATCRBS interrogator antenna. This distance will depend on the area of the reflecting surface and its desirable to site the interrogator at least half a mile away from large metal structures. Although it may be desirable to associate the interrogator antenna physically with a primary radar antenna, siting and maintenance considerations may make it necessary to have a separate site for the interrogator. When this is necessary, the rotation of the two antennas should be synchronized with a maximum error not to exceed one degree.

10.3.2.2 Interrogator Antenna

10.3.2.2.1 It is necessary that the side lobe level of the antenna relative to the main lobe be as low as practicable. A level lower than -24 dB is desirable. It is important that the interrogation beamwidth be kept as narrow as possible, normally of the order of three degrees, but it should be noted that there is a minimum number of replies necessary for processing and display. This minimum will depend on the particular processing and display facilities provided, but would, typically, fall in the range of 4 to 8 replies per beamwidth on each interrogation mode

10.3.2.2.2 Side lobe suppression requires two radiation patterns: a directional pattern to radiate the interrogation pulses, and an omni-directional pattern to radiate the control pulse. It should be noted that "omni-directional", as used here, assumes that adequate power is radiated in all directions, not necessarily that equal power is radiated in all directions. It is necessary that the control pattern be in the right relationship to the interrogation pattern over the operational angles of elevation. This may demand that the antennas be designed in a common assembly so that the same effective height above the ground can be maintained for both.

10.3.2.2.3 Some antenna sites may experience severe reflections from buildings and re-siting may not be practicable. If the reflections are not adequately suppressed by side lobe suppression, satisfactory performance is possible by use of modified three-pulse side lobe suppression techniques. One technique makes use of the omni-directional antenna during transmission of the P_1 interrogation pulse. The P_1 interrogation is fed to both the directional and omni-directional antennas in a power ratio depending on the particular reflection problem and assists transponder suppression in the side lobe areas.

10.3.2.5 Sensitivity Time Control (STC)

This feature is extremely effective in minimizing the undesirable processing and display of side lobe replies from older transponders that do not have side lobe suppression (SLS) capability. Even with the SLS fully implemented, the use of STC will be required to minimize the effects of reflected signals and pulse stretching. The setting of STC is critical since too much attenuation will cause target loss and too little allows reflection and side breakthrough. Once an optimum setting is determined, it should be maintained with close tolerance. A tolerance of ± 1.5 dB is recommended.

10.3.2.6 Rejection of Unwanted Responses

10.3.2.6.1 In an area where a large number of ground interrogators are necessary, there will be a considerable number of transponders responses, which have been triggered by other interrogators, received at any one ground equipment. The responses will be received at recurrence frequencies which will, in all probability, be different from that of the interrogator receiving the information and will constitute a nuisance call "fruit" (unsynchronized replies) on the radar display.

10.3.2.6.2 Defruiting techniques which use delay lines, storage tubes, or digital storage to defruit on a pulse-to-pulse basis should be employed to remove these non-synchronous replies. The defruiting function may also be an integral part of the digital detection process.

10.3.2.7 Monitoring of ATCRBS Interrogator

10.3.2.7.1 The performance monitoring of the ground interrogator called for in 10.2.10 is required to provide responsible personnel with an indication that the equipment is functioning satisfactorily within the system limits and to give an immediate indication of any significant fault developing in the equipment. Additionally, it is desirable that continuous monitoring provisions with respect to at least the system parameters listed hereafter in 10.3.2.7.1.1 and 10.3.2.7.1.2 be provided and that an alarm indication be given in the event of a failure of the monitor itself.

10.3.2.7.1.1 Pulse Intervals

Means should be provided to measure pulse spacing for all modes which are to be employed.

10.3.2.7.1.2 Interrogator Relative Radiated Pulse Levels

When side lobe suppression is provided monitoring of this parameter is most important and should be associated with the tolerances indicated in 10.2.5.

10.3.2.7.2 Monitoring of the following ATCRBS system parameters is also desirable; however, checking on a periodic basis should suffice.

10.3.2.7.2.1 Interrogator Radio Frequencies

Assuming that a high stability crystal controlled oscillator is used as the frequency control element of the ATCRBS, it will be necessary only on a periodic basis to determine that the tolerances specified in 10.2.1 are satisfied.

10.3.2.7.2.2 Interrogator Pulse Duration

10.3.2.7.2.3 Receiver Sensitivity

10.3.2.7.2.4 Radiated Power

10.3.2.7.2.5 Spurious Radiation

10.3.2.7.2 The precise location of the monitor warning indication is a matter for determination by the Administration concerned in the light of local circumstances, but should take into account the need to prevent the presentation of erroneous information to the controller without his knowledge.

10.3.3 Airborne Equipment

10.3.3.1 Transponder Peak Power Output and Sensitivity

System requirements can be met by a transponder having a nominal output power of 500 watts (peak pulse) an a nominal minimum triggering level (MTL) of -74 dBm, when used in an aircraft having a nominal 3 dB transmission line attenuation and mismatch loss and an antenna performance equivalent to that of a simple quarter-wave antenna. Other combinations of transponder peak pulse power output and MTL, transmission line loss and antenna performance, which result in comparable installed system effective radiated peak pulse power and MTL may be considered equally acceptable.

10.3.3.2 Antenna

10.3.3.2.1 A technique which uses two transponders connected to separate antennas must be considered with extreme caution. Such an arrangement, unless carefully controlled, could result in unsatisfactory performance because of the difficulty of matching transponder parameters. This technique requires matching of the relevant characteristics specified in 10.2.7 and in particular, matching of the reply delay (10.2.7.11) to within 0.2 microsecond.

10.3.3.2.2 Any switching device that alternately changes the transponder from one antenna to another at a preset rate should be avoided. A preferred method, if dual antennas are used, is through received signal amplitude comparison whereby the transponder reply is routed to the antenna which receives the stronger interrogation signal.

10.3.3.3 Transponder Self-test and Monitor

If self-test and or monitor devices are installed and used in aircraft to indicate normal or faulty operation, care should be exercised to minimize any system derogation (particularly fruit generation) that may result. The duration of use of the test mode should be an absolute minimum and limited to that required by the pilot to determine the transponder status. In order to minimize suppression of replies to ground interrogations, the test signal interrogation rate and level should be the lowest practicable for test.

10.3.3.4 Pressure-altitude Transmission

10.3.3.4.1 In order to achieve maximum operational benefit from automatic pressure-altitude transmission, the altitude information used by the pilot and that automatically provided to the controller must closely correspond (10.2.7.13.2.5). The highest degree of correspondence will be achieved by having airborne systems which use the same static pressure source, same aneroid unit, same static pressure error correction device and same scale correction device for both the pilot and the automatically transmitted pressure-altitude data.

10.3.3.4.2 For aircraft installations which are not yet equipped with altitude digitizer units, the use of Mode C reply framing pulses only (10.2.7.13.2.2) is encouraged as an interim arrangement.

10.3.3.4.3 The wording of the standard recognizes that facilities are provided on many transponders in service which only enable the information and framing pulses to be removed together. But its main objective is to ensure that inaccurate information pulses are removed while retaining the capability of position determination. The framing pulses alone are useful in certain ground processing equipments for enhancing the detection probability and azimuth accuracy.

10.3.3.4.4 The capability required by the standard at 10.2.7.13.2.2 should be provided in new installations.

10.3.3.5 Automatic Conversion of Pressure Altitude Data to Altitude.

Automatically transmitted pressure-altitude data obtained via ATCRBS may be displayed to air traffic controllers directly after being decoded when such data indicates that the aircraft from which it is received is at or above the transition level. When the aircraft is below the transition level such data could be misleading, since it is based upon the standard atmospheric pressure reference datum of 29.92 inches of mercury, while the pilot's altimeter is adjusted to a different reference. In this case, therefore, the data must be converted by application of an appropriate correction factor based upon the same reference datum as that to which the pilot's altimeter is set.

10.3.3.6 Transmission of the "X" Pulse

In 10.2.6.2, the position of the "X" pulse is specified as a technical standard to provide for possible future expansion of the system. It is recognized that though a majority of airborne transponders of later design contain an "X" pulse position, there are no means at present embodied to permit the operational use of this pulse. To do so, modifications of existing transponders and/or ancillary equipment would be necessary. The extent of modifications required would depend on the future function of the "X" pulse.

10.3.3.7 Transponder Low Sensitivity Setting

Many existing transponders are equipped with a low sensitivity setting (minus 12 dB below normal sensitivity) which is manually selectable by the pilot upon request of the controlling agency. This feature has been found useful as an interim technique for reducing transponder side lobe response. However, SLS is being implemented at interrogator sites and the low sensitivity feature will not be needed in new transponders.

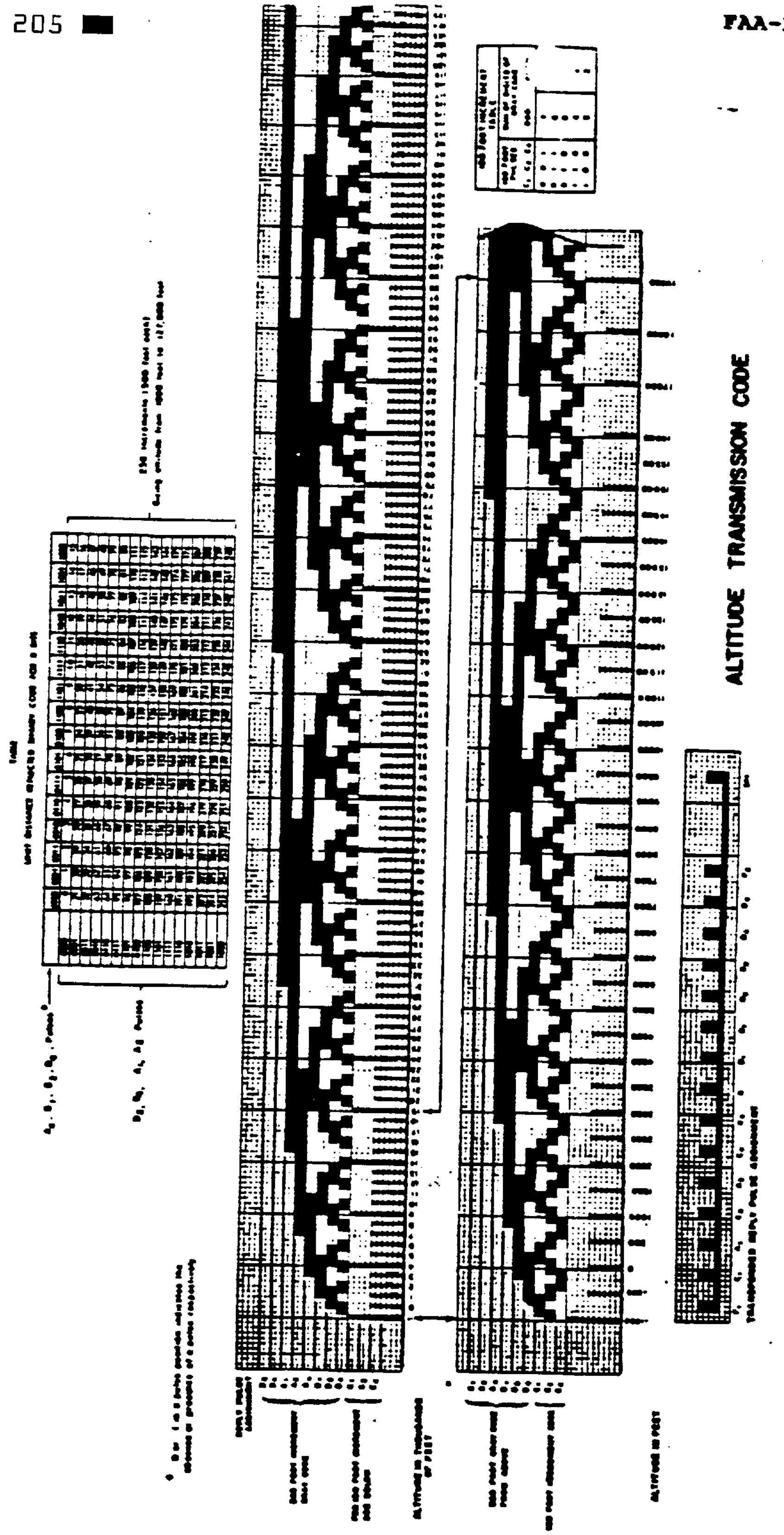

FIGURE I

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FIGURES

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